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ABSTRACT

Planning models are one set of techniques used in the process of planning and budgeting in higher education. Their use in examining budget alternatives has increased as expenditures in higher education have increased. It is an important premise of the discussion of planning models that the manager must participate actively in the construction and implementation of models that serve as decision-making aids. This examination of institutional resource allocation is divided into four parts: part one examination is a description of resource allocation models from the United States, West Germany, Portugal, and the Netherlands that represent different modeling philosophies; part two examines the concept of program planning and budgeting used in all the models described in part one; part three gives an overview and detailed discussion of model implementation; and part four summarizes the discussion. (Author/MSE)

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STUDIES IN INSTITUTIONAL MANAGEMENT IN HIGHER EDUCATION

INSTITUTIONAL RESOURCE ALLOCATION MODELS IN HIGHER EDUCATION

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STUDIES IN INSTITUTIONAL MANAGEMENT
IN HIGHER EDUCATION

INSTITUTIONAL RESOURCE ALLOCATION MODELS IN HIGHER EDUCATION

by
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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
1976

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PREFACE

Over the past few years, a considerable amount of effort has been expended to devise new and better ways of resolving administrative and planning problems faced by universities and other higher educational institutions. As a result of research into, and experimentation with, new methods and approaches to university management, a certain amount of basic knowledge and management expertise has been accumulated in a number of problem areas. The subject of this book is limited to one such area, namely the design and implementation of resource allocation models for institutions of higher education. It is an outgrowth of the first two in a series of professional training seminars organised by OECD's Programme on Institutional Management in Higher Education to introduce university personnel with management responsibility to some basic concepts and approaches to university management.

In October 1973 the first seminar was held on the theme "Programme Budgets for University Management and Planning". This seminar consisted primarily of a set of lectures on several sub-topics of this theme, although these lectures were complemented by presentations of practical cases chosen to illustrate the basic principles being covered. During this seminar, a small number of participants volunteered to take part in an experimental decision-making exercise (game) involving the use of a computerized mathematical model. The enthusiasm shown by those who participated led to the decision to devote the second seminar to an expanded exercise of this kind. This seminar, held in November 1974 and entitled "Models and Simulated Decision Making for Institutional Management in Higher Education", used two simulation models extensively. These were the Total University System Simulation (TUSS) model, developed in the Netherlands, and the Resource Requirements Prediction Model (RRPM), developed in the United States.

A considerable amount of documentation was produced for each of these seminars, prepared in large part by the author of this publication, who has revised, edited and supplemented the original papers to make them available in the present form. It is intended to introduce managers in higher education to concepts of formal modelling approaches to planning and budgeting in higher education. The problems which arise in implementing such models are also addressed and possible solutions discussed.

The roles of a number of organisations and individuals in the first preparation of the publication should be acknowledged. Firstly, it should be noted that the professional training seminars were made possible as a result of a grant of $100,000 from The Ford Foundation covering a two-year period. Secondly, the co-operation of the Hochschule-Information-System GmbH, the State University of Utrecht and the New University of Lisbon in providing information on the models which they developed, is most appreciated. Finally, individuals who made important contributions to the seminar presentations and its documentation are: Messrs. Hans de Nie, James Farmer, Hans Freytag and Charles Thomas.

J.R. GASS
Director
Centre for Educational
Research and Innovation

Chapter 1

INTRODUCTION

The Centre for Educational Research and Innovation at the OECD recently conducted two seminars for managers and administrators in higher education. One was entitled "Programme Budgets for University Management and Planning", and the other "Models and Simulated Decision Making for Institutional Management in Higher Education". Seminar attendants expressed great interest in the topic of planning models in higher education.

They asked for additional papers on this subject, asking particularly for more information on allocation models developed in Europe and on the implementation of all allocation models. This book has been written in response to these requests.

Planning models are just one set of techniques used in the process of planning and budgeting(1) in higher education. Their use in examining different budget alternatives has increased as expenditures in higher education have increased. In the U.S. these education expenditures are projected to increase from 54.8 to 76.3 billion dollars (in 1967-68 dollars) over the period 1966-77. (Simon, et al., 1969). As in many OECD countries, U.S. requests for educational funding must compete with funding requests from other sectors of the economy, especially welfare, energy, and environmental control needs. Due to this competition funding agencies are increasingly demanding justification of financial requests before allocating funds, and they are examining different alternatives of resource allocation. It is here that planning models can be useful. Models can simulate the consequences of different sets of alternatives. The simulation model does not in itself find the best or optimal solution to funding problems but it does provide additional information to aid decision-makers in making choices between alternatives. The models do not replace the decision-maker's judgement or experience. They merely help him by providing relevant information.

It is essential that the decision-maker be knowledgeable about the models he uses. It is an important premise of this book that a

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1) These terms and the process are defined in Lockwood (1972).

manager must participate actively in the development (construction and implementation) of models which serve as decision-making aids. Such participation ensures effective use and prevents misuse of models. If the decision-maker does not formulate the assumptions of his model and does not determine the values of policy variables that are inputs to the model, it is very likely that he has abdicated many important policy decisions to the model builder or the analyst. The decision-maker must not abdicate this responsibility because it has potentially significant consequences. This position has been argued by many organizational theorists and confirmed by numerous empirical studies. (Garrity, 1963 and Reichenbach, et al., n.d.). However, a decision-maker must be knowledgeable about planning models before he can participate in model design and implementation. Providing such knowledge is the objective of this book.

Outline of the Book

This book is divided into four parts. Part One is a description of resource allocation models. Two of these models are from the U.S. (Chapter 2), and one each from West Germany (Chapter 3), Portugal (Chapter 4), and the Netherlands (Chapter 5). The models discussed represent different modelling philosophies. Studying them will enable the decision-maker to identify the model or parts of a model that are relevant to his environment and his style of decision-making. He can then communicate his model needs to the model builder. This will reduce the communication gap between manager and technician and improve the probability that the model developed is relevant and useful.

Part One is also addressed to the model builder. He need no longer construct models in existing isolation but can benefit from developments in other countries. There are many features of each of the models discussed which can be used in other countries despite differences in national educational systems. The cross-fertilization of ideas among model builders should increase the usefulness of models in higher education.

Part Two examines the concept of programmed planning and budgeting used in all the models discussed in Part One. This is done in Chapter 7. Part Two also discusses planning models that support the resource allocation models discussed in Part One. The first of these chapters is a survey of all these models (Chapter 8). The second is a detailed examination of one of these models, the cost and costing model (Chapter 9), emphasizing the potential use and possible misuse of planning information. Chapters 7 through 9 are addressed primarily to the manager and user of models.

Part Three is on the implementation of models. An overview of the process (Chapter 10) is followed by a detailed discussion of some phases of implementation: data generation (Chapter 11); organizational changes (Chapter 12); and the use of game models for training (Chapter 13).

Part Three is addressed to both the analyst and the manager. The analyst collects the needed data but the manager specifies the data definitions, the limiting values and the data sources; the analyst tests the model but the manager specifies the validation strategies and standards of validation; the analyst identifies the organizational changes needed for effective use of the model but the manager makes the necessary changes; the analyst prepares an educational program on the model and the manager participates in the program. This close relationship is necessary for the model to be successfully implemented and used.

Implementation will vary with each model and each institution. It is a heuristic process. However, there is a body of knowledge and a set of experiences that is emerging from recent implementation of models in higher education. Studying these should make model implementation faster and cheaper and also less painful.

A Summary and Conclusions chapter will be found in Part Four.

Organization of the Book

Some of the papers presented at the OECD seminar have been included in this book without any change in content. These are "The HIS Model" (Chapter 3), by Hussain and Freytag, on "Gaming Models" (Chapter 13), by Hussain, and "Why Cost Analysis for Higher Education" (Chapter 9), by James Farmer. One chapter on "Why PPBS?" (Chapter 7) was written previously by James Farmer, one of the teaching staff members of the OECD seminar. There are other papers presented by Hussain that have been rewritten and updated. These include a paper on CAMPUS and PRIM (Chapter 2), a comparison of models (Chapter 6), and a paper on allocation related models (Chapter 8). The remaining chapters have been written specifically for this book. These are the chapters on the allocation models MSAR and TUSS (Chapters 4 and 5), on implementation (Chapters 10-12), and the summary and conclusions (Chapter 14).

Each chapter in this book has been written to be independent of preceding chapters and of those that follow. This results in some duplication of definitions but enables readers to study chapters of the text selectively or in a piecemeal fashion. To locate sections of individual interest and to get an overview of the entire book, the reader is advised to read the introductions to each of the three main parts and the summaries found at the end of most chapters. In addition, Chapters 6 and 14 are summary chapters.

There are no mathematical prerequisites to reading this book. All mathematical calculations have been reduced to the four basic arithmetic operations: addition, subtraction, multiplication, and division. The relationships between these calculations are represented in flow diagrams with some repetition in alternative representations.

Where mathematical and procedural material is required for a chapter, it is included in an appendix and appears immediately after the chapter. This occurs for the TUSS model (Chapter 5) and the Gaming Models (Chapter 13).

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PART ONE

INTRODUCTION

Part One examines a selected set of five resource allocation models. Two models from America have been selected for their generality and comprehensiveness: CAMPUS and RRPM. The remaining three models are the only ones currently implemented in Europe: HIS (West Germany), MSAR (Portugal) and TUSS (Netherlands).

These models will be examined in this text for the logic of their basic computations. Special modules and features unique to each model will also be outlined and implementation considerations will be discussed.

CAMPUS and RRPM, the earliest two models developed, are discussed in a single chapter (Chapter 2) because they have much in common. The other models appear in the following order: HIS (Chapter 3), MSAR (Chapter 4), and TUSS (Chapter 5). The final chapter of this part (Chapter 6) is a critique of all these models, including a comparison of their comprehensiveness, basic logic, planning factors, maximum dimensions, and some technical data. The chapter concludes with a general critique on the usefulness and limitations of the current state of model building.

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CAMPUS AND RRPM

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1. INTRODUCTION

Use of formal planning models is a relatively recent development for higher education. A survey done in 1970 (Weathersby and Weinstein, 1970)(1) identified 31 such models. Of these eight were resource allocation models and only two of these were operational. They were CAMPUS V (Judy & Levine, 1965) and CSM (Weathersby, 1967). Since then, there has been considerable activity in planning models and in the use of program planning and budgeting (Balderston and Weathersby, 1972, Weathersby and Balderston, 1972, and Farmer, 1970). CAMPUS has been reprogrammed and now appears in many different versions; CSM has been the main basis of the development of a set of models called RRPM: while other models in development during the 1960s have now become operational. Of all these models developed in America there are two that are generalised enough to be of great interest to the European audience of this chapter. These models are CAMPUS, the most comprehensive and detailed, and RRPM that is the most accessible and commonly used. These models will be examined in terms of their historical growth, their structural similarities and differences as well as for their implementation and use. Selected models other than CAMPUS and RRPM, developed in the U.S., will then be surveyed briefly. For the reader interested in pursuing these and other models further, numerous references are provided.

2. HISTORICAL DEVELOPMENT OF CAMPUS AND RRPM(2)

CAMPUS is an acronym for a "Comprehensive Analytical Methods of a Planning in University Systems". It has its origin in the academic work on simulation in higher education done by Judy and Levine. They developed and now market CAMPUS through the firm, the Systems Research Group (now called SDL). The work started on CAMPUS in 1964 at the University of Toronto. It continued under a grant of 3/4 million dollars by the Ford Foundation resulting in CAMPUS V(3) (Judy, 1969, Judy and Levine and Centner, 1970) being released in 19[illegible].

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1) For another similar survey, see Casasco (1970), Van Wijk (1972) and Wartgow (1973).

2) Part of this section appears in Hussain and Freytag (1975).

3) For a discussion of the development of CAMPUS I-IV see Judy, R.W., et al.: "Systems Analysis for Efficient Resource Allocation" in Minter, et al. (1969).

But CAMPUS V was hardly used. Why? Because it was badly documented and because it was very costly - both development and operating costs. The development costs were high because of the large mass of data required by the model including resource data on each activity - a set or subset of a course that required a unique set of types of resources. These were used for computations that were done mostly by one main program(1) that led to high operating costs, especially when answering "what if" questions in the simulation mode. Also, most of the data had to be kept in memory requiring a very large computer. For the University of Illinois, this was estimated at 4 million bytes, recently reduced to 300,000 bytes as a result of much reprogramming. Thus CAMPUS V was beyond the reach of almost all institutions except the large and the daring. These included SUNY at Stony Brook and the University of Illinois. The University of Minnesota also implemented it on a pilot basis (in one school of a university, one state college and one junior college, Andrew, 1971 (b)). But, CAMPUS V did perform an important service to higher education. It demonstrated the feasibility of a comprehensive cost simulation model that could improve decision-making in planning and budgeting. What was needed, however, was a model that made more modest demands on data, equipment and analytical effort so that it could be within the reach of most institutions of higher education.

To achieve such an objective, the United States Office of Education funded a proposal for model development by NCHEMS (National Centre of Higher Education Management Systems) at Western Interstate Commission for Higher Education in the U.S. This product is known as RRPM-1 Resource Requirements Prediction Model.

RRPM 1.2 was the first operational version. It was a modification of the CSM model (Weathersby, 1967)(2) made by the staff of NCHEMS and a national task force. It was implemented by eight pilot institutions selected to represent the different types and sizes of institutions in the country. As a result of the pilot testing, further modifications were made and RRPM 1.3 was released in mid-1971 (Hussain and Martin, 1971).

Since RRPM 1.3 was a generalised model, there were other specialised versions planned. Versions 4 and 5 were to be specialised for

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1) The word "program" has at least three meanings. It is a description of academic content such as the program of study taken by a student. It is also a description of activities at a cost centre such as the Program of Financial Aid, Physics, Chemistry, etc. This term is sometimes spelled "programme". Finally, a program is a set of instructions written by a computer programmer. This last definition relates to the term as used above.

2) For a critique of CSM see Hopkins (1969 and 1971) and for a response to the critique see Andrew (1971 (a)).

the community colleges and the state colleges, respectively. But instead a sixth version PRPM 1.6 was released. This involved reprogramming and re-arranging data by discipline rather than function. This decreased core requirements (along with the fact that it does store only non-zero data) in spite of the relaxation of constraints on the dimensions of student programs and disciplines. This made its use independent of the type of institution using it. It is also conceptually simpler than PRPM 1.3 because it has no space-management capability and has fewer relationships for support costs. It was implemented in 1972 (Huff, 1972) and was released to the public in early 1973. Both versions 1.3 and 1.6 are now operational and are maintained by NCHEMS.

Meanwhile, CAMPUS underwent considerable changes. Its first generalised version of CAMPUS V was completely reprogrammed as CAMPUS VI and was made modular. This greatly reduced its operational costs and core requirements. But data was still required at the activity level. However, the input format was changed and its documentation was greatly improved making data preparation much easier. CAMPUS VI was later reprogrammed as CAMPUS/COLORADO(1) and CAMPUS VIII, making them more modular, more flexible in their dimensions, with additions in the costing routines and a better handling of the research sector. Another version CAMPUS IX is still further modularized with an additional Budget Review model but conceptually simpler than CAMPUS VIII.

In addition, CAMPUS VII was implemented mainly in Ontario Community Colleges. This version does not require data at the activity level and hence has further reduced core requirements and operational costs. It is designed for institutions requiring data only at the aggregated level of department or above.

In summary: there are many versions of each of the two families of models being examined: versions 1.3 and 1.6 for PRPM: and versions VII, VIII and IX for CAMPUS. But PRPM 1.3 and CAMPUS VIII are conceptually the more comprehensive of their family of models and as such will be the basis of most of the discussion that will follow. Differences in the other operational models, when significant, will be identified.

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1) CAMPUS/COLORADO is a version for CDC equipment and designed to incorporate special features relevant to Colorado (Andrew, 1972, Hussain, 1972). The logic of CAMPUS/COLORADO is more fully described in Appendix I, to be found at the back of the book.

3. BASIC LOGIC OF MODELS

The basic logic common to both the RRPM 1.3 and CAMPUS VIII is shown in Figure 2.1(1). A textual explanation of this figure appears in section 3.1 below. The readers who find Figure 2.1 self-explanatory can skip section 3.1 without any loss of continuity.

3.1. Basic logic explained

There are some terms that need to be defined to the European reader. These terms are "credit-hour", "student program", "program contact-hour", "activity", "student-credit-hour", "student-contact-hour" and "full-time-equivalent".

In the United States and Canada, a "credit-hour" is a unit of academic achievement. When a student satisfies the requirements of a course (a presented set of content) which is typically an exam, he then gets accredited to his academic record a specific amount of credit-hours for that course. When he completes a set of courses (which may include electives), and accumulates at least a minimum number of credit-hours, he then gets an academic award such as a diploma or a degree. A specific set of courses (required or electives), each carrying a specific value of credit-hours, leading to a specified objective is often referred to as a "student program". In the above case, each course is a "program element". But the program element can be other than a course as occurs in non-academic programs. Thus formally, a "program" can be defined

> "to be a collection of programme elements serving a common set of objectives. A programme element is defined to be the lowest level distinct management unit that comprises a collection of resources, technologies, and policies which, through their integrated operation, produce goods or services, i.e. an output, which is of value to the organisation because it contributes to the achievement of an institutional objective ... the programmes of the institution must be organised in such a fashion that management can exercise control over the inputs, the processes, the extent of resource utilisation, and the outputs of each programme" (Gulko, 1972: 4-5).

Back to the concept of the credit-hour. Typically, the "credit-hour" for a course is equal to the hours that the course needs for a lecture every week. Thus a course having lectures three hours a week has three "credit-hours". Some courses, however, have instruction other than lectures, such as a lab (laboratory) required for

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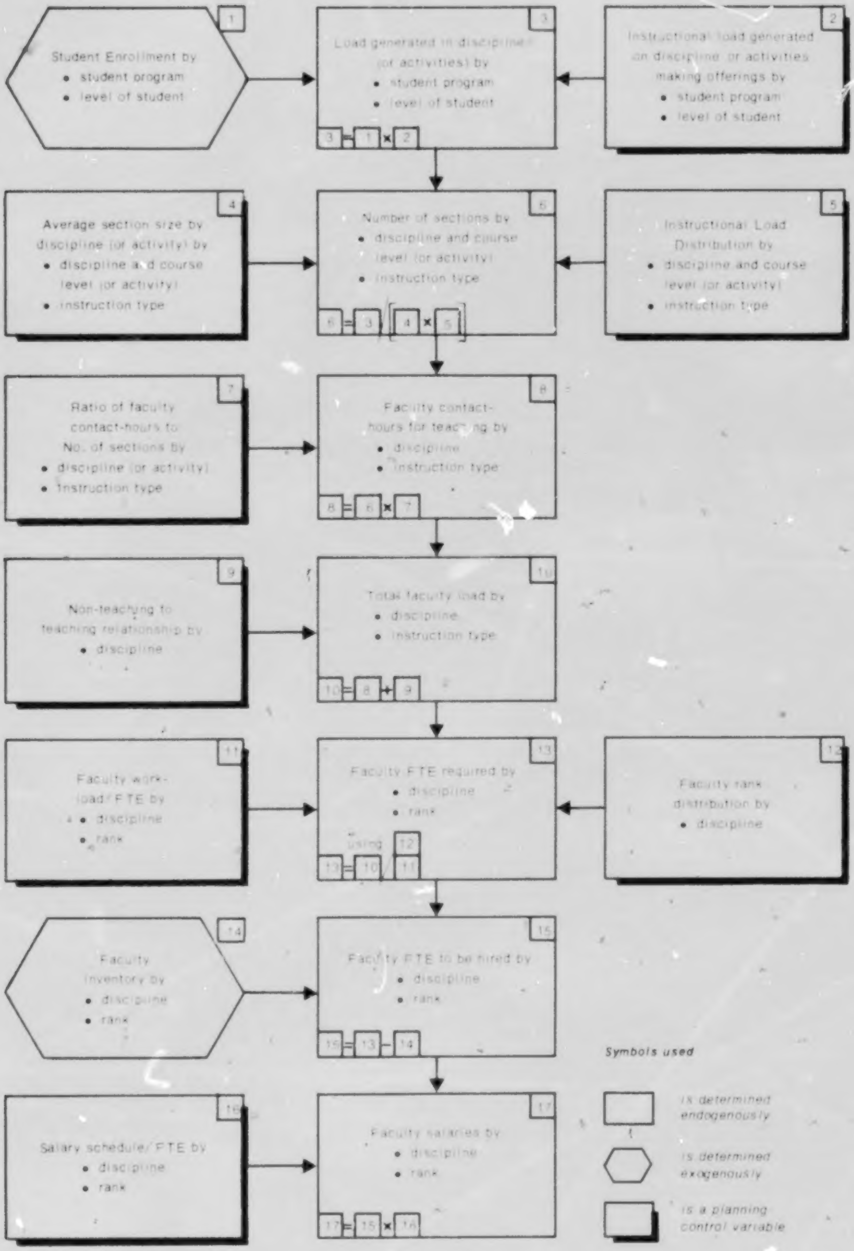
1) For details on the logic and numerical examples illustrating the logic of CAMPUS, see Hussain (1972). For numerical example solutions of RRPM 1.2, see Hussain (1971), pp. 9-12, 70-92.

Figure 2.1

BASIC LOGIC FOR CAMPUS AND RRPM


1
Student Enrollment by
• student program
• level of student
3
Load generated in discipline (or activities) by
• student program
• level of student
3 = 1 × 2
2
Instructional load generated on discipline or activities making offerings by
• student program
• level of student
4
Average section size by discipline (or activity) by
• discipline and course level (or activity)
• instruction type
6
Number of sections by
• discipline and course level (or activity)
• instruction type
6 = 3 / [4 × 5]
5
Instructional Load Distribution by
• discipline and course level (or activity)
• instruction type
7
Ratio of faculty contact-hours to No. of sections by
• discipline (or activity)
• instruction type
8
Faculty contact-hours for teaching by
• discipline
• instruction type
8 = 6 × 7
9
Non-teaching to teaching relationship by
• discipline
10
Total faculty load by
• discipline
• instruction type
10 = 8 + 9
11
Faculty work-load/FTE by
• discipline
• rank
13
Faculty FTE required by
• discipline
• rank
using 12
13 = 10 / 11
12
Faculty rank distribution by
• discipline
14
Faculty inventory by
• discipline
• rank
15
Faculty FTE to be hired by
• discipline
• rank
15 = 13 − 14
16
Salary schedule/FTE by
• discipline
• rank
17
Faculty salaries by
• discipline
• rank
17 = 15 × 16
Symbols used
is determined endogenously
is determined exogenously
is a planning control variable

many courses in the Sciences. But typically three hours a week of lab has only 1 or even 0 credit-hours since the lab does not typically have the same intellectual content as a lecture. But the meeting-hours a week is an important quantity for planning resources since that determines the resources consumed. It needs to be uniquely identified. It is called "contact-hours" since it represents the physical contact made with resources such as personnel, space and perhaps even equipment.

In many cases, the lecture and the lab are different courses and there is no problem of identification. In some cases, however, a course may have some lectures and some lab and then there is in some models the need to identify them separately since they consume different sets of resources. This identification is done in a model like CAMPUS, by referring to each part of the course as an "activity". Thus a course, Physics 101, meets for a 3-hour lecture and a 2-hour lab, but the lab is worth only 1 credit-hour. This course is then identified as two activities: one lecture activity, call it Physics 101 with 3 credit-hours and 3 contact-hours; and another activity, call it Physics 101 L, which has 1 credit-hour and 2 contact-hours. The course Physics 101 in this case has a total of 4 credit-hours and 5 contact-hours.

The "credit-hour" and "contact-hour" in itself is not an output of education. However, when one student earns a credit-hour it is a measure of output and is referred to as one "student-credit-hour". Similarly, when one student makes one contact-hour he generates one "student-contact-hour".

In many undergraduate institutions, a student studying full-time takes a total of 15 credit-hour courses per semester or term. This generates 15 student-credit-hours, and is referred to as one full-time equivalent or FTE. Similarly, the term "FTE" is used for faculty and staff and enables the aggregation of part-time staff into full-time persons. Thus two half-time persons are 1 FTE; also, 3 persons working 1/3 full-time each are 1 FTE.

A numerical solution showing sample calculations of the above terms is given in Figure 2.2.

The logic of the basic model as represented in Figure 2.1 can be re-stated as in Figure 2.3 where only the main computations and their flow are shown and no inputs are identified. This figure could be instructive if read backwards, i.e. starting with the need to calculate costs of faculty (teaching staff), we need to determine FTE faculty and to determine this we need to calculate the sections needed which in turn requires the determination of the student load. This logic holds true for any level such as an activity (as in CAMPUS) or a more aggregate level such as discipline or department (as in RRPM). In all cases, the main computation that one must do

Figure 2.2

A PROBLEM ON TERMINOLOGY AND ITS SOLUTION

Problem: Calculate the output of the courses Theology 452 and Chemistry 102 given the following data:

1 FTE student = 15 student-credit-hours

Theology 452

Meets 3 hours weekly and 3 credit-hours
Has 30 students

Chemistry 102

Meets 3 hours weekly for lecture and
4 hours weekly for lab with
2 hours credit (for lab)

Has 20 students for the lecture and
15 students for the lab.

Solution:

	Theology	Chemistry		Source
		102	102L	
(1) Credit hours	3	3	2	Given data
(2) Students	30	20	15	Given data
(3) Student-credit-hours	90	60	30	(3)=(1)x(2)
(4) FTE student	6	4	2	(4)=(3)/15
(5) Contact-hour	3	3	4	Given data
(6) Student-contact-hour	90	60	60	(6)=(2)x(5)

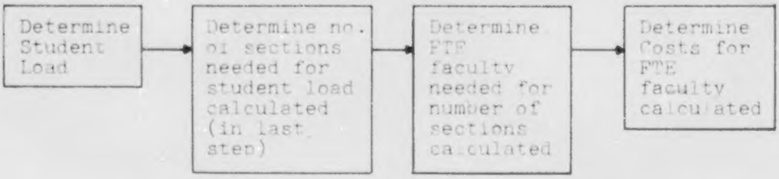
first is determine the student load, i.e. the number of students in an activity, discipline or department.

Now we return to the detailed flow chart of Figure 2.1. In it the student load (corresponding to box 3) is determined by multiplying student enrollment (box 1) with the instructional load (box 2). The student enrollment is by student program which is an academic output such as a degree, diploma or other academic award. Typically it is identified for each level of the student such as 1st year, 2nd year, etc. Thus a student program could be the first year of a chemistry degree.

The instructional load are the courses or activities generated by each student program. An example of this is shown in Figure 2.4. In it, student program 1 generated a 3 contact-hour load in discipline 1 or activity 1; a 1 contact-hour in discipline 2 or activity 2; and so on for a total contact-hour load of 15 hours.

Figure 2.3

AGGREGATE REPRESENTATION OF BASIC MODEL


Determine Student Load
Determine no. of sections needed for student load calculated (in last step)
Determine FTE faculty needed for number of sections calculated
Determine Costs for FTE faculty calculated

Similarly, programs 2 and 3 induce a total load of 18 and 12 contact-hours, respectively, for each of its student enrollments of 200 and 100 students, respectively.

The matrix (or table) identifies the course or activity load "induced" (or generated) and hence is sometimes called the Induced Course Load Matrix. It is, however, the load for one student in each student program. When this load (box 2) is multiplied by the student enrollment in each student program (box 1) it gives the load generated in disciplines or activities (box 3).

Figure 2.4

AN ICLM (INDUCED COURSE LOAD MATRIX)
(in contact-hours)

Student Programs

	No.1	No.2	No. n
Discipline No.1	3	2	0
Discipline No.2	1	4	2
.			
.			
.			
.			
Discipline No.m			
Total contact hours for each student program	15	18	12

This is perhaps the most important (computationally) and most difficult (conceptually) part of the model, so let us illustrate this with an example. Let us consider a student enrollment as 200 students in the 1st year Art and 120 students in the 3rd year Physics as student programs 1 and 2. Also, consider the ICLM as that given in Figure 2.4. Then the load computations will be as follows:

Student-Contact-Hours generated by student program 1:

In discipline 1 = No. of students in Student Program 1
X no. of contact-hours in discipline 1

= 200 X 3 = 600

In discipline 2 = 200 X 1 = 200

Student-Contact-Hours generated by student program 2:

In discipline 1 = 120 X 2 = 240
In discipline 2 = 120 X 4 = 480

The total student-contact-hours generated in each discipline is now a sum of the load generated by it for each student program. Thus far, the student-contact-hours (St. Co. Hrs.) generated are:

In discipline 1 = St. Co. Hrs. by student program 1
+ St. Co. Hrs. by student program 2

= 600 + 240 = 840

In discipline 2 = 200 + 480 = 680

This is an illustration of the determination of load generated by disciplines (or activities) (box 3 in Figure 2.1). It is in student-contact-hours because the units of the ICLM is in contact-hours. If the ICLM is given in credit-hours, then the results of computations as shown above would be student-credit-hours and need to be converted into student-contact-hours by a ratio of contact-hours to credit-hours for that discipline or activity.

The next important computation is the determination of the number of sections (box 5). This is done for every discipline or activity and for each instruction type such as lecture, lab, seminar, etc. To determine this, we divide the student load (box 3) by the load distribution for each discipline and instruction type (box 5). This is also divided by the average section size (box 4) which is by each discipline (or activity) and instruction type (the average section size varies with instruction type and is typically larger for lectures and smaller for laboratory classes).

We could check the units of our calculation here. We started with student-contact-hours of faculty load (box 3) and divided it by the contact-hours of the ICLM (box 5) to give us units of students. This is divided by the unit of students in the average section size (box 4) giving us a pure number which is the unit of the number of sections (box 6).

The next important computation is the determination of the faculty FTE required (box 15). This is done in three steps. First, we calculate the faculty contact-hour generated by discipline and type of instruction (box 8). This is done by multiplying the number of sections (by discipline and course level and instruction type) calculated previously (box 6) by the contact-hours for each section concerned (box 7).

Now the second step. We need to calculate faculty load in FTE (box 10). This load is the sum of teaching load calculated previously (box 8) and the non-teaching load given by a teaching to non-teaching relationship (box 9). This is done for each discipline and instruction type.

We are now ready for the last step on the calculation of faculty FTE required by discipline and instruction type (box 13). First the faculty FTE (box 10) is distributed into ranks (e.g. Professor, Assistant Profess, etc.) by a rank distribution parameter (box 12) which varies with discipline. This is divided by the work load for each FTE (box 11) given by discipline and rank.

The faculty required by discipline and rank (box 13) is compared with the available inventory (box 14) (determined externally to the model) and the difference is the faculty FTE needed (or in surplus) by discipline and rank. We now approach the final calculation: determination of faculty salaries (box 17). This is done by multiplying the faculty to be hired by rank (box 15) with the faculty salary schedule (box 16) which is also by discipline and rank. This gives us the additional faculty salaries (box 17) by discipline and rank.

3.2. Differences in the Basic Logic

There are many minor differences that do not appear in Figure 2.1 and have been deleted in order to keep the figure simple. An example is the computation of instructional load. In the RRPM, this is calculated in credit-hours and is then converted to contact-hours by a ratio of contact-hours to credit-hours. This conversion is not done in CAMPUS which has all its activity loadings in contact-hours. It is also unnecessary in RRPM if the student loading is done in contact-hours to start with.

There are many other such minor differences that will not be discussed. There are, however, two main differences in the logic of RRPM and CAMPUS. They concern the level of detail in instruction loading as well as in planning factors. These will be discussed in turn.

3.2.1. Level of detail

The instructional loading in RRPM is done through an induced course load matrix representing the credit or contact-hour-load induced by a student major on different levels of courses that are offered by different disciplines or departments. In CAMPUS the load induced is in terms of specific courses or activities and are in contact-hours. The detailed level of activity does generate a variety of reports that can be very valuable, especially in costing, which will be discussed later. It also enables planning at the most elemental academic organizational level and involves all organizational levels in the planning process. However, there is a price that must be paid: the massive detailed data input required at the activity level. This is shown for CAMPUS in Figure 2.5.

In the case of the University of Colorado, using CAMPUS VIII, there are over 2,200 activities and for each activity up to 16 data elements on resource loadings have to be specified. These data must be collected (typically on forms), converted to machine-readable data, stored, processed, and maintained. The maintenance cost (especially on the mix of activities required for each student program) could be high for institutions where student preferences change or where course requirements change significantly. It is difficult to predict in cases of new student programs and degrees. It is even difficult to specify the activity mix in order to maintain status quo. This is due to the fact that the student load and activity mix vary not only between semesters but also among types of programs such as daytime and evening programs. The mix can be unstable even at the aggregated level of the ICLM; as was experienced by the pilot institutions of RRPM 1.3 (Hussain, 1971, pp.27-28) and other ICLM studies. (Jewett et al., 1970 and Hussain et al., 1972). These studies show that the greater the disaggregation of the ICLM, the more the instability. This instability will increase as students demand and get more electives and unstructured degree requirements. This will increase the problems of predicting new course mixes and the redistribution of old ones that are dropped.

3.2.2. Planning variables

The detailed level of data required by CAMPUS occurs throughout the model and is reflected in the planning variables. As an example, consider the determination of the number of sections required. In RRPM and CAMPUS, the number of sections is determined by dividing the student load by the average section size and using some rule for accounting for the left-overs. In CAMPUS, however, the solution is also subject to many constraints such as maximum class size, minimum class size and maximum number of sections. This adds to the control and flexibility for the user but it requires that all the constraints be specified as planning variables (one set for each activity).

For some institutions this choice of planning variables is often unnecessary and this has been recognized in RRPM 1.6 where the faculty FTE can be calculated by an option that uses a weekly credit-hour (or contact-hour) load by level of course, thereby eliminating the

Figure 2.5

THE DATA ELEMENTS REQUIRED FOR EACH ACTIVITY IN CAMPUS

- credit-hour (per term or semester)
- contact-hour (hours per week)
- type of activity (lecture, lab, seminar, etc.)
- resources required
    - personnel
    - type (professor, graduate assistant, etc.)
    - equipment
    - space
        - type
        - size
- duration in weeks
- identification data
    - name and/or number
    - discipline offering it
- level of activity
- location
- maximum number of sections
- minimum enrollment allowed
- section size policy

planning factors of average section size, credit to contact-hour ratio, distribution of contact-hours, distribution of faculty rank, and average faculty work load by rank.

There are other planning factor differences between CAMPUS and RRPM. These are listed in Figure 2.6. One set found in CAMPUS VIII enables the "flowing" of faculty between time periods, using rates of turn-over, sabbatical and promotion policies, contract lengths, and availability periods. CAMPUS VIII maintains a faculty inventory for each time period (these capabilities of faculty flow and inventory have been dropped in CAMPUS IX). It also allows for substitution among ranks within a cost centre but not any substitution among discipline specialities within ranks.

4. THE MODEL (continued)

There are three parts of the model other than that shown in Figure 2.1. One part is a Student Flow Module that goes in front; one part calculates non-teaching salary costs and goes at the end; and is followed by a third part, the costing module. Each will now be discussed.

Figure 2.6

A COMPARISON OF PLANNING FACTORS

	CAMPUS VIII	RRPM 1.5
INSTRUCTIONAL:		
• Student programs	• by detailed course/activity mix	• by mix of credit-hrs • in dept/discipline
	• resource loading of each activity • space • personnel type • time of offering	• loading of groups of courses at different levels and fields • space • equipment
	• section size • average • maximum • minimum	• section size • average
	• maximum no. of sections	
Faculty	• substitution policy	
	• contract length	
	• turnover rates and hiring policy	
	• sabbatical policy	
	• weekly availability	
	• promotion policy	
	• average salaries by rank	• average salaries by rank
	• rank distribution	• rank distribution
	• academic level	• academic level
	• workload weights	
	• administrative load	
SPACE:	• substitution policies	• (not in RRPM 1.6)
	• availability	• availability
	• utilisation	
	• type	• type
	• size	• size
	• construction coefficients	• construction coefficients

4.1. The Student Flow Module

This module determines the student enrollment in each student program at each level of student's academic achievement. It is part of the CAMPUS package and determines the flow of students through the system by using pass-fail rates at each level, repeat-rates between programs. (For an excellent survey, see Lovell, 1971). This is conceptually similar to the Student Flow Model developed by NCHEMS and designed to interface with RRPM (Johnson, 1970). Following the NCHEMS tradition this model was developed by its staff supported by a national task force, tested at selected pilot institutions and implemented successfully (Huff et al., 1972). The NCHEMS student flow model and the one in CAMPUS have much in common: both can be by-passed if desired; both use data on freshmen enrollment and transfers as exogenous variables; and finally, both have problems and issues raised by using the transition matrix. Some of these issues include: the definition of points and student states most suitable for the transition matrix; the calculation, aggregation and stability of transitional probabilities; and the validity of the Markovian assumption for student transitions. These issues are part of the ongoing research and development work being done at NCHEMS.

4.2. Non-Salary Costs

Non-salary costs are calculated in both RRPM 1.3 and CAMPUS VIII at the cost centre level. This requires the estimation of both the relationship and the cost coefficients at the cost centre level. This is no trivial task. At the University of Colorado, the implementation of CAMPUS requires stating 2,800 equations and estimating cost coefficients. Over 43 variables were used in these relationships, most of them being endogenously determined. (CAMPUS VIII allows up to 130 such variables and 13,000 equations.)

The problem of estimation (and validation which becomes difficult when the accounting system does not keep costs by programs) can be by-passed by using one cost equation for all support cost at each cost centre. This is done in RRPM 1.6.

4.3. Costing

Both CAMPUS and RRPM calculate costs for academic and support staff at the program and sub-program levels. In addition, in CAMPUS VIII the costs are aggregated by budget function and object category. This facilitates preparing annual line-item budgets for financial control both needed in addition to program budgets for analysis and decision-making.

Both CAMPUS and RRPM calculate unit cost for student programs. In addition, CAMPUS calculates the direct cost for each activity.

This is aggregated for each activity in the activity mix of each student program and gives program costs. In RRPM, the study program cost is determined as the inner-product of average cost of credit-hour by discipline and the ICLM. The average cost figure, however, may result in student programs using less than average cost-courses in the discipline being over-priced and programs using higher-than-average-costs being underpriced. This possibility does not occur in CAMPUS because of its detailed activity level costing data.

Indirect costs are allocated to primary programs (Instruction, Research and Public Service) in both CAMPUS and RRPM 1.3 but not in RRPM 1.6. In CAMPUS, there are options as to some allocation rules: by a specified percentage; in proportion to the direct cost of the receiving categories; or a combination of the above two rules. But in most cases these rules are not logical nor equitable. Such allocation rules are the subject of an NCHEMS study on Cost-Finding Principles (Ziemer, et al., 1971). It has software that will allocate support costs to primary program and can be used as costing module independently or in conjunction with RRPM(1).

5. DIFFERENCES BETWEEN CAMPUS AND RRPM

5.1. Dimensions

Many differences between RRPM and CAMPUS have been identified above. Other differences are in the dimensions of the model. These are shown in Figure 2.7. Some differences of a technical nature are listed in Figure 2.8. Other main differences concern the Revenue Model, Capital Budget, Output Reports, and Implementation considerations. These are discussed below:

5.2. Revenue Module

CAMPUS is the only model with a Revenue Module in which revenue from students is estimated as a function of projected enrollment and tuition rates. Revenue from public funding agencies is calculated by formula which in many cases must be restated and reprogrammed in order to meet local needs. The revenue components can be projected from year to year either by an absolute value or by a given percentage change. The model does not include important components such as financial aids, and portfolio management(2). What it does include is grants, gifts, endowments and special revenues which are treated exogenously instead of making them a function of endogenous variables such as student enrollment number, type of student programs, etc.

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1) For its implementation in conjunction with RRPM 1.6, see Huff et al., (1972), pp.21-36.

2) For one research formulation of this, see T.W.Ruefli (1970).

Figure 2.7

A COMPARISON OF MAXIMUM DIMENSIONS(1)

	CAMPUS		BRPM	
	VII	VIII	1.5	1.6
Student Programs	20	350	90	200
Academic Disciplines or Depts (Teaching Cost Centres)	30	100	90	200
Non-academic Depts (Non-teaching Cost Centres)	10	25	-	-
Activities	0	4000	0	0
Course Levels	1	(implicit in activity specification)	4	7
Instruction Type	3	9	4	5
Student Levels	4	8	7	7
Faculty Ranks	5	10	5	6
Non-academic Ranks or Classifications	7	150	4	4
Space Type and Size Ranges				
academic	8	125	2	0
non-academic	10	110	4	0
Non-personnel				
Resource types	7	120	5	7

1) Source of Data: Van Wijk and Russell (1972), p.35: K.M. Hussain (1971 (a)); Clark, et al., (1971), p.6.

Figure 2.3

A COMPARISON OF SOME TECHNICAL DATA

	CAMPUS		RRPM	
	VII	VIII	1.3	1.6
Program Language Used	FORTRAN IV	FORTRAN IV	FORTRAN & COBOL	COBOL (ANSI)
Equipment Used	Most computers upward of an IBM 1130	IBM CDC	IBM CDC UNIVAC	IBM CDC UNIVAC BURROUGHS
Minimum Core Requirements (thousand bytes)	16	256	128	50 for DOS 65 for OS
Cost of Software				
purchase	$12,500	$25,000	$50.00	$50.00
lease	$ 3,000 + 350/m for 36m	$ 6,000 + 700/m for 36m		
Consulting services for overall project management, training of senior staff and adaption of planning manuals	Varies from $5000 to $50,000		NCHEMS provides limited training at nominal cost. Other help in implementation is a function of the supply and demand on its staff.	

Source of Data: SRG (1972), pp. 48, 50, 51 and Van Wijk and Russell (1972), pp. 32-35 on CAMPUS: Hussain (1971) on RRPM 1.3 and Clark (1972), p. 31, RRPM 1.6.

5.3. Capital Budget

Both RRPM 1.3 and CAMPUS VIII calculate the incremental cost of expenditures resulting from projected increase in space requirements. To calculate this, however, CAMPUS VIII (not VII) has a greater facilities-planning capability. It "shuffles" rooms around according to given space substitution and utilisation policies; calculates net shortages and surpluses of space by type; calculates space utilisation; and finally maintains inventories of rooms by size and types.

CAMPUS VII calculates the square feet of space and number of stations required for its eighteen space types. RRPM 1.6 has no space management or capital budgeting capability.

5.4. Output Reports

All versions of models considered here have sets of output but they vary greatly in number and content. The output in RRPM and CAMPUS VII aggregated for the discipline or department level. CAMPUS VIII, in comparison, is detailed. Also, CAMPUS has by far the most comprehensive set of reports. The output is particularly good for space management and on administrative indices on loading, costing and utilisation. It has an extensive set of reports on the validity of data that is valuable in data generation.

No model prepares plottings as part of its computer output but data from the tables can readily be plotted manually. This is done for CAMPUS and is shown as samples in Figures 2.9-2.12(1).

RRPM 1.3 also has a unique report. It identifies on one page the results of ten sets of changes made in the "what if" experimentation mode(2). The display of results facilitates an analysis of incremental changes and of sensitivity analysis. For such experimentation the user may make blanket changes by percentage or an absolute value in addition to replacing one or more values. CAMPUS and RRPM 1.6 allow only a percentage blanket change and only for a select set of variables.

RRPM 1.3 has a TRACER-TRAINER routine that "traces" all the intermediate output for any one selected discipline. This is useful not only in training a user on how the model handles his data but also in debugging and in validating the model.

An institutional implementation of RRPM 1.3 has the TRACER on a terminal in the programmed instructional mode along with routines to help the uninitiated user. CAMPUS VIII also has a CAI (Computer Aided Instruction) package. It has an interactive prompter which is especially helpful to the user.

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1) These figures are taken from a run of CAMPUS. However, the data has been slightly altered and some details of the source purposely suppressed in order to maintain confidentiality of the data.

2) For a sample, see Gulko and Hussain (1971), pp.30-33.

Figure 2.9

PROGRAM CATEGORY STUDENT CONTACT-HOUR COSTS BY BUDGET FUNCTION 1972

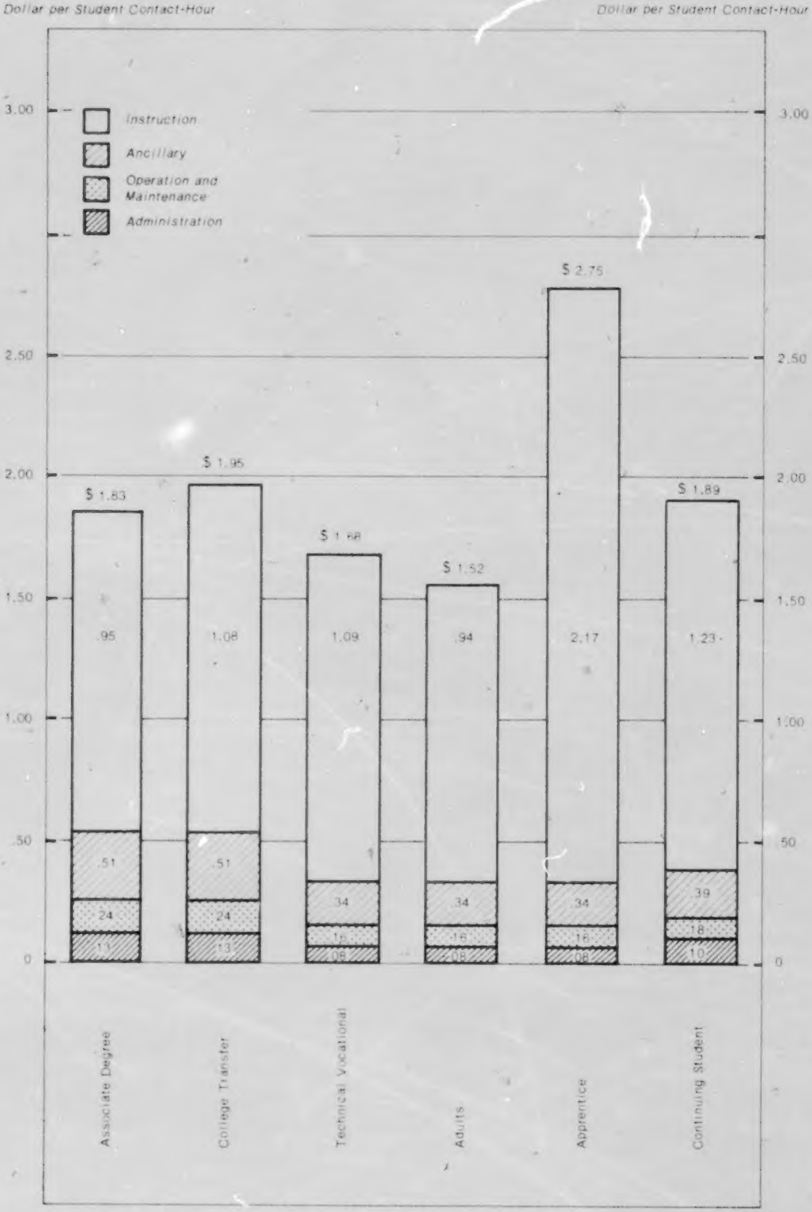
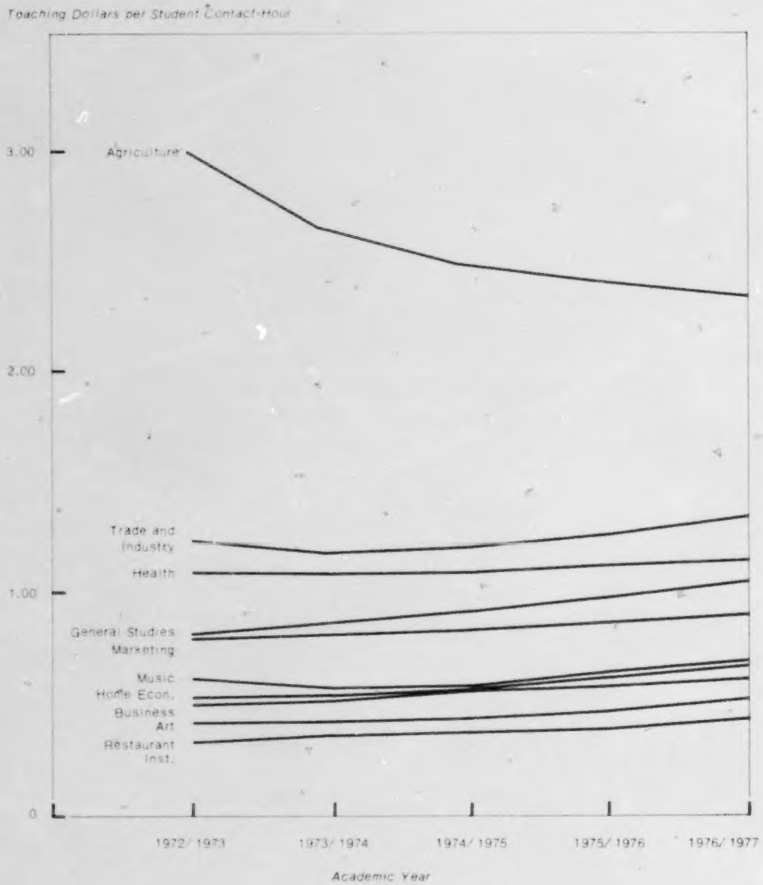


Figure 2.10

TOTAL TEACHING SALARIES PER STUDENT CONTACT-HOUR BY ACADEMIC DIVISION 1972-1976



Both RRPM and CAMPUS can answer "what if" type questions that would help the educational administrator. Some of these are:

A. Staffing Changes
  - What if the current staffing ratio of support personnel was increased or decreased by 10 per cent?
  - What if the average faculty load in a given college was increased to the average of other colleges?
  - What if there was an X per cent raise in faculty salaries and a Y per cent raise in non-faculty salaries?

- What if a change is made in the mix of instructional faculty? (Such changes might be in the ratio of full to assistant professors or the use of graduate assistants in recitations instead of assistant professors).

3. Curriculum Changes (Note: A curriculum change typically requires extensive modifications to other curricula).
   - What if a new degree program was to be added and another were to be dropped?

Figure 2.11

PERCENTAGE CHANGE IN INSTRUCTIONAL SPACE AND TOTAL SPACE 1972-1976

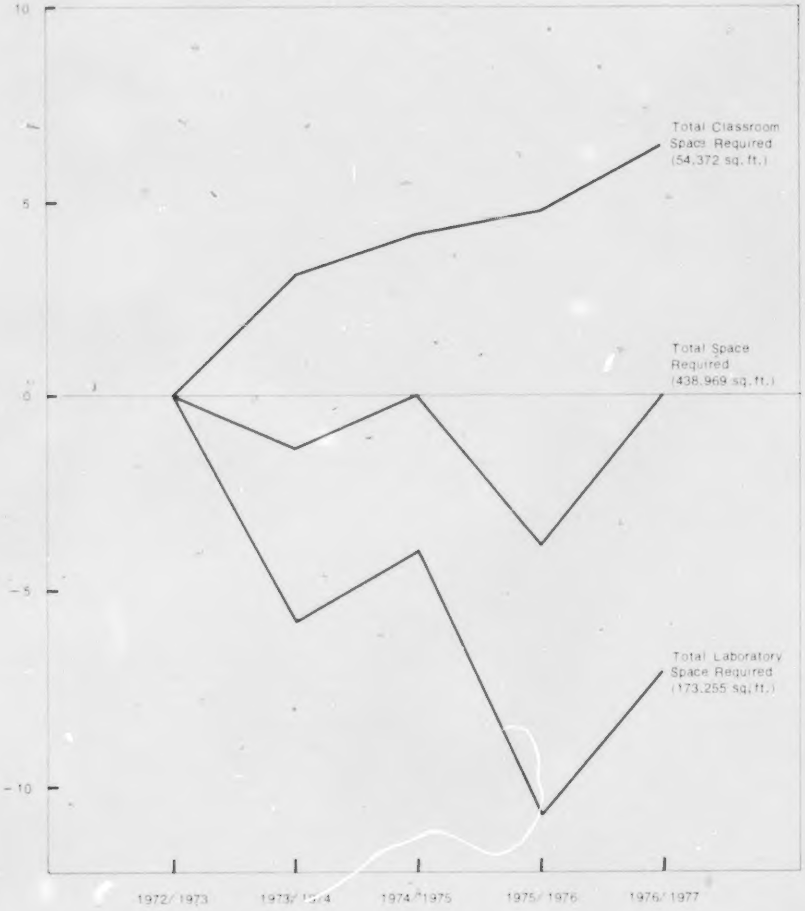
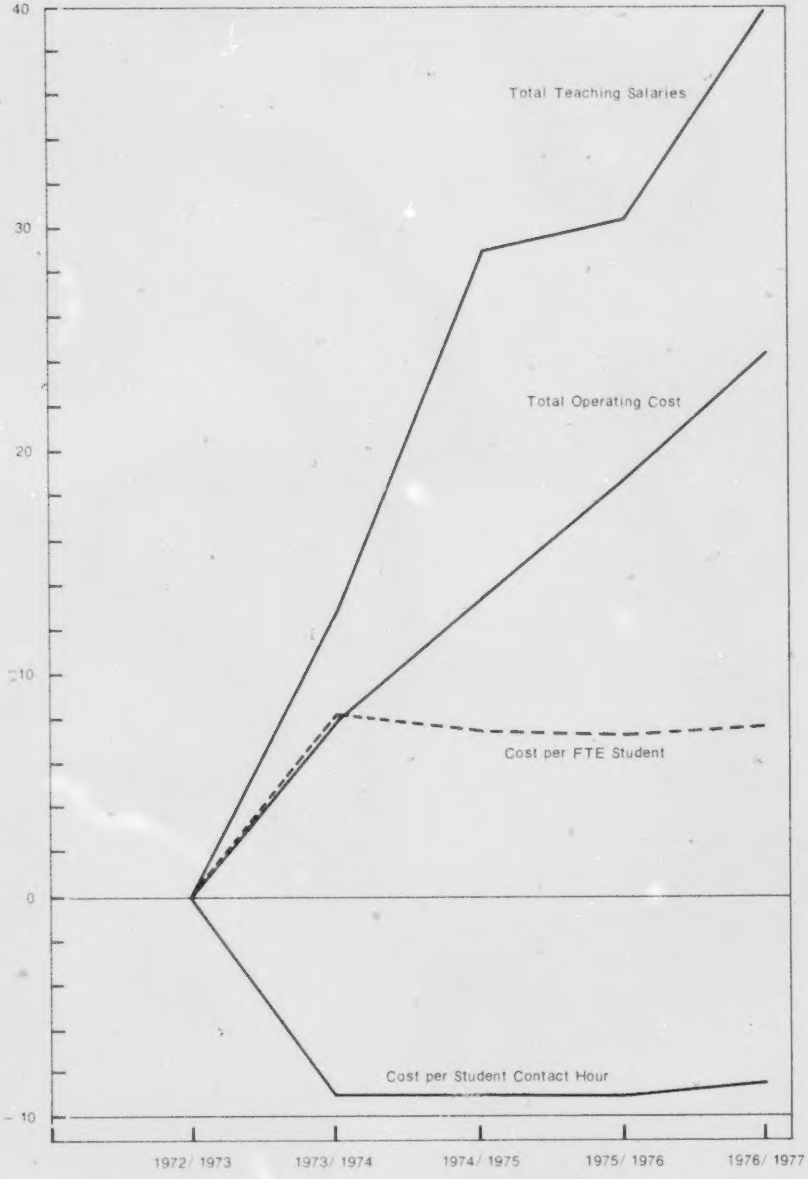


Figure 2.12

CUMULATIVE PERCENTAGE INCREASE IN ADMINISTRATION COLLEGE INDICES
1972 - 1976



- What if a service discipline (not offering a degree program) was added?
- What would be the effect on the math. service courses(1) if the junior college transfer sector was to increase by 60 per cent?
- What would be the effect on the English department if the English Composition requirements for math. majors were removed?

C. Admissions Policy

- What if a specific change is made in the mix of students either by degree program or by level or both?
- What if the institution limits its admission in various fields three years from now?
- What if the enrollment for a given level of students was eliminated or initiated?

D. Other

- What if there were additions or deletions to existing programs in Research and Public Service?
- What if one or more of the factors in space or construction were to change?
- What if the cost relationships for travel, equipment and supply were to be altered?
- What if the library costs per student were increased by 10 per cent?

The resource implications of questions like some of the above may be answered only to a limited degree. Clearly, there are other subjective implications which reflect upon the quality of operations such as effects on students' contributions to society, and impact on faculty values. The state-of-the-art in modelling has not advanced sufficiently to deal in a quantitative manner with this aspect of planning and programming changes. However, the ability to compute rapidly the resource implications of alternatives will lead, hopefully, to a more ordered and structured consideration of the subjective aspects of higher education.

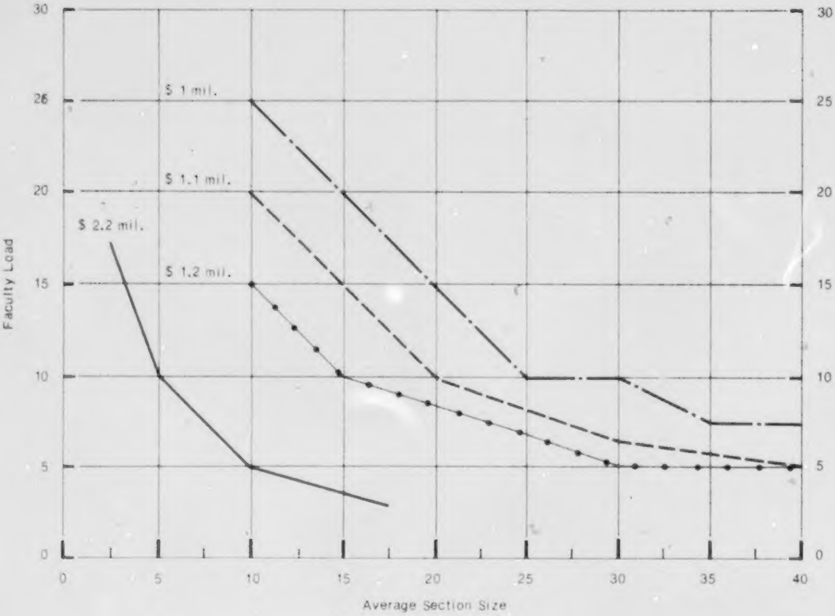
One case where RRPM 1.2 was actually used in decision-making by asking the "what-if" question is illustrated in Figure 2.13. In this case, the administrator asked for the trade-off between faculty load and class size given a fixed salary of $1,100,000. A set of pairs of values for faculty load and class size were generated and is shown in Figure 2.13. (The points are joined for illustration; the curve

---

1) Courses that are offered as a common service to all disciplines that need that course instead of that course being taught in each discipline.

Figure 2.13

TRADE-OFFS BETWEEN FACULTY-LOAD AND AVERAGE SECTION SIZES FOR DIFFERENT BUDGET LINES



is not continuous). Once an area of interest or feasibility is identified, then more points on the same budget line could be generated. Similarly other sets of trade-offs are calculated for varying budget lines and these are also shown in Figure 2.13. Such curves were very valuable in graphically demonstrating the trade-offs involved.

5.5. Cost of Development

The one-time cost of development is difficult to ascertain for CAMPUS since it is now the property of a firm and such data is not available. Some data are available, however, for the development of RRPM and this concerns the cost of pilot implementation. This varied with all the eight institutions reflecting the different environment and the status of data base. Some averages and ranges are presented in Figure 2.14 and give some clues to the magnitudes involved in the pilot implementation of a new model. It must be emphasized that these figures include much experimentation and development and are much higher than the cost of implementing an existing version of RRPM.

Figure 2.14

COST OF DEVELOPING RRPM BY PILOT INSTITUTIONS

	Unit	Average	Range
Direct Cost	$	27,616	9,510 - 43,000
Indirect Cost	$	26,951	12,174 - 62,1[illegible]
Manpower			
Management	man-months	2,900	1,000 - 7,000
Analyst	man-months	11,800	2,700 - 19,000
Programmer	man-months	12,400	3,000 - 41,000
Other	man-months	3,200	0 - 10,000

NOTE: The lapse time from the date of funding to the completed implementation of the first pilot study was 37 months.

Source of Data: Hussain and Martin (1971), pp.14-17.

5.6. Cost of Implementation

In evaluating models, one should look at their cost effectiveness ratios. The effectiveness of a planning model, however, cannot all be quantified. Its implicit value could, however, be compared to costs and a judgement could then be made as to whether or not it is worth the cost.

In calculating the costs, one must differentiate between development and operating costs to the institution. Development costs include the cost of software shown in Figure 2.8. Other development costs include costs of changing the model to meet institutional needs, validating the changes, data generation and training. Typically, the largest component is that of data preparation. This, in turn, depends largely upon the type and quantity of data required. This could be compared for actual implementations of the model to be compared, but such comparisons invite suspicion since institutions to be compared are often different in structure and complexity. To overcome this problem, one could compare the data generation problem for each of the models. This is done for four types of institutions whose institutional characteristics are compared in Figure 2.15. Their data generation problems are compared in Figure 2.16.

Data generation is important not only in estimating development costs, but also in estimating operational costs. Such costs increase greatly when data elements are updated annually. In a cost study done for CSM (the conceptual basis for RRPM), Hopkins found that the annual updating of the data base more than doubles the annual operating costs of maintaining the model (Hopkins, 1969). Maintenance of the data base is necessary in order to reflect the changing values of many of the parameters in the model. In a study of some departments in Berkeley, a study by Bremenan found that the faculty requirement coefficients vary as much as 200 per cent from one year to the next (Bremenan, 1969).

Figure 2.15

CHARACTERISTICS OF INSTITUTIONS COMPARED (FOR 1971-72)

	Multi-Campus University		State	Community
	Main Campus	Branch Campus	College	College
Student FTE (Average for Semester/Quarter)	18,632 (Semester)	2,263 (Semester)	5,284 (Quarter)	2,400 (Quarter)
Highest Degree Offered	Ph.D.,	Masters	Masters	Associate
Student Programs	275	26	65	58
Cost Centres - Academic	53	12	46	11
Cost Centres - Non-academic	47	9	20	21
Academic Activities	2,200	724	1,200	244
Instruction Types	9	6	4	2
Student Levels	3	6	6	1
Course Levels	5	5	5	1
Faculty Rank	9	5	8	1
Non-Academic Rank	38	15	33	5
Space Types	70	29	15	15
Other Resource Categories	19	10	10	3
Other Resource Subcategories	56	31	4	7

Changes to parameters also result during experimentation when making simulation runs. This increases the operational cost (the cost of each simulation run is shown in Figure 2.16, which is a necessary cost if one wants to investigate the consequences of possible changes).

Other components of operational costs result from the need for continuing analysis of output, and the need for training the user. These components are very important aspects of implementation and are not sufficiently recognized. The estimate for this effort is also shown in Figure 2.1 . It will vary with institutions and is a function of their planning experience; the support that they can get from other departments such as the Computer Centre; the number or nature of modifications to the model initiated by the user and the Computing Centre; the extent of the use of the model; and finally the thoroughness with which the task is performed.

In Figure 2.16, the figures for CAMPUS VIII are based on empirical data. The figures on the remaining models were estimated by the writer and colleagues who are as knowledgeable about the institution and very knowledgeable about implementation of the models concerned. The figures were then checked against published data on implementation. Unfortunately, there are not much data on the implementation of RRPM 1.6 and CAMPUS VII since these are relatively new models and

Figure 2.16

COMPARISON OF COST-RELATED ELEMENTS

	Multi-campus University								State College				Community College			
	Main Campus				Branch Campus											
	CAMPUS		RRPM		CAMPUS		RRPM		CAMPUS		RRPM		CAMPUS		RRPM	
	VII	VIII	1.3	1.6	VII	VIII	1.3	1.6	VII	VIII	1.3	1.6	VII	VIII	1.3	1.6
Data Elements in ICLM (in 000's)	18	1815	18	18	0.3	19	0.3	0.3	3	78	3	3	0.6	14	0.6	0.6
Regression Equations for non-teaching salary costs		2000	300			630				2400				600		
Development Costs(1) in 000's of $	12	30	35	7	4	20	25	5	10	26.4	32	7	4	20.7	24	6
Run Cost in $ for one complete set of reports(2)	3	500		3	2	200		2	2	300		3	2	200		2
Maintenance Cost in Analyst FTE	2.0	3.0	1.5	1.0	0.25	0.5	0.75	0.5	0.75		1.0	0.5	0.75	0.5	0.5	0.25

1) These costs do not include the cost of administrators working on the model, cost of software, consulting or overhead. Some of it may be sunk cost.

2) These costs need not be out-of-pocket costs, especially if the model becomes part of the "normal" operations of the institution.

have few implementations. The number of implementations of these and other models are shown in Figure 2.17.

6. OTHER ALLOCATION MODELS

Figure 2.17 shows the implementation for HELP/PLANTRAN as well as CAP: SC/SEARCH, since they are also resource allocation models with more than one application each. These models will be discussed briefly below. However, before doing so, mention must be made of other specialised models. These include the TULANE University model (Firmin et al., 1967); a model for the University of Washington (Koski, 1968); FACSIM and RCM for the United States Air Force Academy (Van Wijk and Russell, 1972, and Allison, 1970), GUS, the Generalised University Simulation implemented at the University of Texas (Ruefli, 1970) and CAMPUS/HEALTH, a special version of CAMPUS for medical institutions (Wilson, R., et al., 1969). Studies that have made conceptional contributions to resource allocation modelling include the model for Michigan State University (Koenig, et al., 1968 and 1969); the work on a state-space model (Zemach, 1968) and the continuous work of implementation and re-development going on at NCHEMS.

Planning models developed in Europe other than HIS, MSAP, and TUSS that have been implemented and will be discussed in detail elsewhere are: the resource model (one of the few with a faculty flow module) by Hammer-Jespersen (1972) in Copenhagen and the SOM model developed by OECD (1970). Numerous studies in Europe related to planning and capacity models include: Bessai et al. (1969); Braun, Hammer and Schmid (1969); Caspar et al. (1969); Dietze (1969); Goossens (1971); Krings Finkenstaedt (1969); Menges and Elstermann (1970); and OECD (1969, (a), (b) and (c)).

6.1. CAP: SC/SEARCH

CAP:SC is an acronym for "Computer Assisted Planning for Small Colleges". It has been superseded by SEARCH which stands for "System for Exploring Alternative Resource Commitments in Higher Education" (Keane and Daniel, 1970, and Struve, 1972). These models were developed by the consulting firm Peat, Marwick, Mitchell & Co. in the United States.

This family of models is very similar to the basic computations as shown in Figure 2.1, but is basically more concerned with the policy level than the operational level. It also considers many additional decision variables such as library stations, volumes to be purchased in the library and dormitory space. It also has its own student and faculty flow modules.

Figure 2.17

NUMBER OF IMPLEMENTATIONS (3)

CAMPUS	
Versions V, VI and VIII	42
Version VII	
HELP/PLANTRAN	50
HIS-Versions A and B	2
RRPM	
Version 1.3	70(1)
Version 1.6	175(1)
CEM(2)	115(1)
SEARCH	5
TUSS	1

1) These figures are for programs distributed not necessarily all implemented. NCHEMS does not implement or control the use of its software and hence has no way of knowing exactly how many of its programs have actually been implemented.

2) CEM is a training version of RRPM which after being used for training is also being used for planning in the operational mode. It is conceptionally similar to RRPM 1.5, has smaller dimensions than either 1.3 or 1.6, and has been implemented only on IBM equipment.

3) Source of Data: For CAMPUS, the data came from SRG (1972), p.47, and for RRPM and CEM the data came from the Office of NCHEMS at WICHE in September 1973. Data for PLANTRAN and SEARCH came from Van Wijk and Russell (1972).

The important distinction between CAP:SC/SEARCH and RRPM or CAMPUS is that CAP:SC/SEARCH is specially concerned with the financial statement of a small private institution. It therefore includes consideration of endowment and current fund projections as well as gift income and interest rates.

The interactive mode of SEARCH encourages its use to ask "what-if" type questions. The user has the option of requesting results either for one year or for multiple years.

6.2. HELP/PLANTRAN

HELP stands for "Higher Education Long-range Planning" (Sutterfield, 1971). It was followed by PLANTRAN, an abbreviation for "PLANning and TRANslation" and refers to the "translation of plans into a computerised system" (McKelvey, 1970). These models were developed by Midwest Research Institute. The model is operated in the batch mode and is accessed by over 50 institutions (Van Wijk and Russell, 1972, p.26).

The models are essentially budget simulators. They calculate each line item for cost or resources for each year of the planning horizon with no limit on the number of line items. The line items (and their projections) can be stated or instead projection equations are stated and then the model performs the projections. Any line item for future planning years could be changed (increased or decreased) by an absolute amount, a percentage amount or changed to a stated ceiling value. The line items can be calculated for different levels of aggregation including the course level.

7. SUMMARY AND CONCLUSIONS

In comparing the class of operational models for resource allocation in the U.S. one can identify CAMPUS and RRPM as the two most interesting of them. The models that operate at the discipline or department level are RRPM 1.3, RRPM 1.6 and CAMPUS VII. Among these, RRPM 1.6 is conceptually the simplest and least comprehensive. It is also the cheapest in both development and operational costs. RRPM 1.3 is slightly less comprehensive than CAMPUS VII but is cheaper to develop largely because of the negligible costs for its software. It does, however, require more computer core memory than does CAMPUS VII or RRPM 1.6

CAMPUS (except CAMPUS VII) is the more detailed both in the input required and the output produced. It is, therefore, more suitable for decision-making at the detailed and departmental level (for budget or curruculum planning at the course level) but the price of such capability is larger core requirements and higher costs of both development and operations.

CAMPUS VIII is by far the most comprehensive in terms of detail, scope and the choice of planning variables. It also has the most comprehensive set of output reports that are useful not only in planning and budgeting but also for control and operational management.

A summary of some important differences between CAMPUS VIII and RRPM 1.3 are shown in Figure 2.18. A summary overview of the main modules of the models and the main inputs and outputs is shown in Figure 2.19.

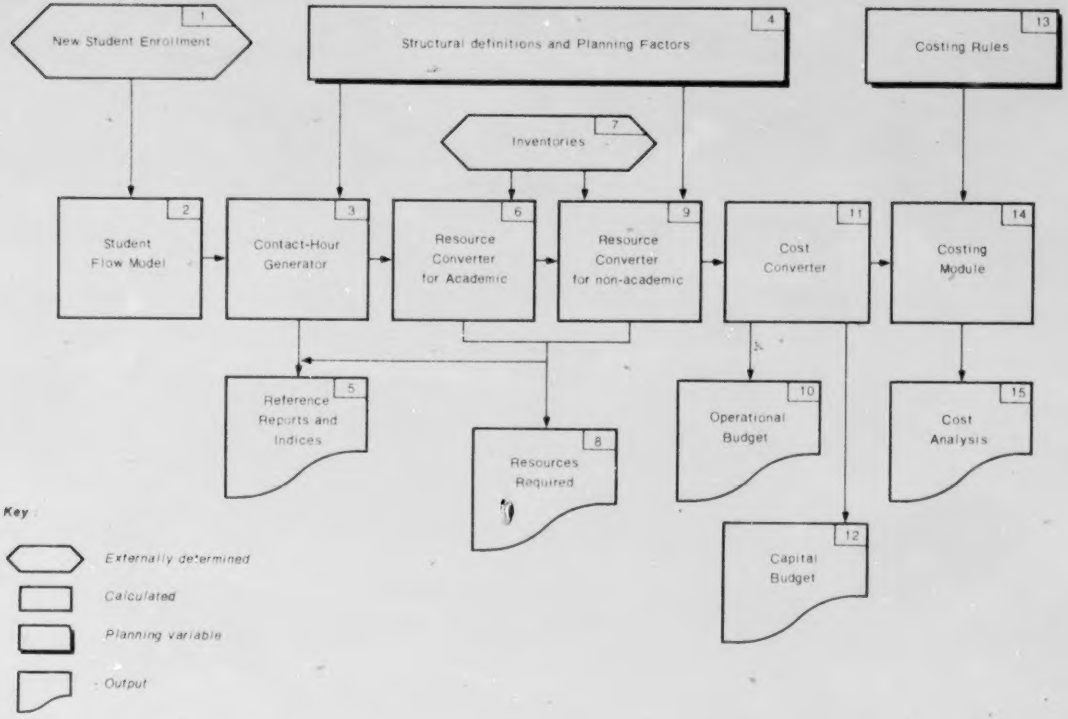
Figure 2.18

SUMMARY OF DIFFERENCES BETWEEN CAMPUS AND RRPM

	CAMPUS VIII	RRPM 1.3
Cost and Costing Model	Yes	Yes
Level of Detail	course/activity	discipline
Non-academic sector included	Yes	Yes
Non-teaching duties weighted	Yes	No
Student flow transitions	disaggregated	disaggregated
Faculty	Flow	None
Special modules	Revenue	Training Game
Planning variable	Many	Few
Output	Good	Adequate
Computer core required	256,000	128,000
Development cost	$25,000 + Consulting	$50

Figure 2.19

COMPONENTS OF A COMPREHENSIVE PLANNING MODEL


1
New Student Enrollment
4
Structural definitions and Planning Factors
13
Costing Rules
7
Inventories
2
Student Flow Model
3
Contact-Hour Generator
6
Resource Converter for Academic
9
Resource Converter for non-academic
11
Cost Converter
14
Costing Module
5
Reference Reports and Indices
8
Resources Required
10
Operational Budget
15
Cost Analysis
12
Capital Budget
Key:
Externally determined
Calculated
Planning variable
Output

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Chapter 3

THE HIS MODEL

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1. INTRODUCTION

This paper describes the model for resource prediction developed by the Hochschul-Informations-System GmbH in the Federal Republic of Germany. This model, henceforth referred to as the HIS model, has two versions: Version A and Version B. Both versions are identical in their basic computational logic. They, however, do differ mainly in the special refinements for specific computations; in the content of output; and in the levels of aggregation of resource prediction. Both the basic logic and the differences in versions A and B will be discussed followed by a critique of the model and an indication of some plans for its future development.

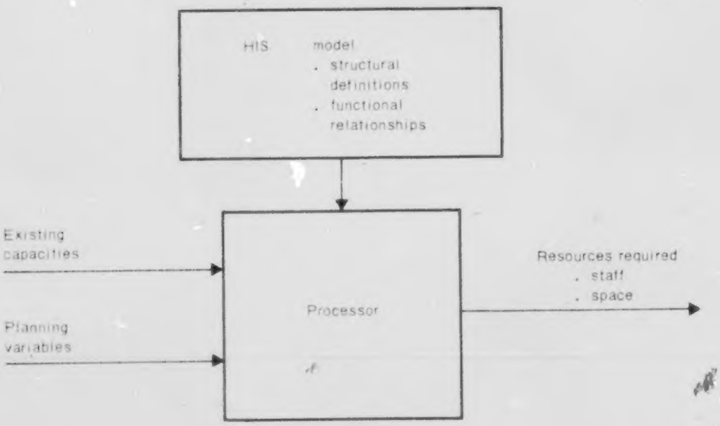
The audience of this paper is an administrator or manager in higher education. Thus no attempt will be made to trace the conceptual development or details of the model (Dettweiler and Frey 1972), nor will there be any discussion of its implementation (Frey 1973).

2. BASIC LOGIC OF THE HIS MODEL[*]

The basic inputs and outputs are shown in Figure 3.1. Only the

Figure 3.1

MAIN INPUTS AND OUTPUTS


HIS model
. structural definitions
. functional relationships
Existing capacities
Planning variables
Processor
Resources required
. staff
. space

---

[*] This paper is co-authored by Hans Freytag.

main inputs and outputs have been identified. But the two types of input must be distinguished in that the structural definitions describe the organization and the categories in which the resources are to be calculated. Some of these structural definitions are listed in Figure 3.2. These inputs as well as the functional relationships (to be discussed later) can be changed but would require changes in the computer program. In contrast, the planning variables are inputs that would typically be changed by the manager or administrator. These are defined externally to the computer program and can be changed very easily. Some examples are listed in Figure 3.3.

Figure 3.2

NUMBER OF STRUCTURAL DEFINITIONS FOR
THE PRESENT APPLICATION PROJECT

Colleges/Schools = 13
Departments = 27
Disciplines = 100
Degrees = 40

Figure 3.3

SOME PLANNING VARIABLES

Planning variables

Faculty

- teaching load
  - value
  - weights
    - lecture
    - preparations
    - grading

Section size average

Student-course relationship

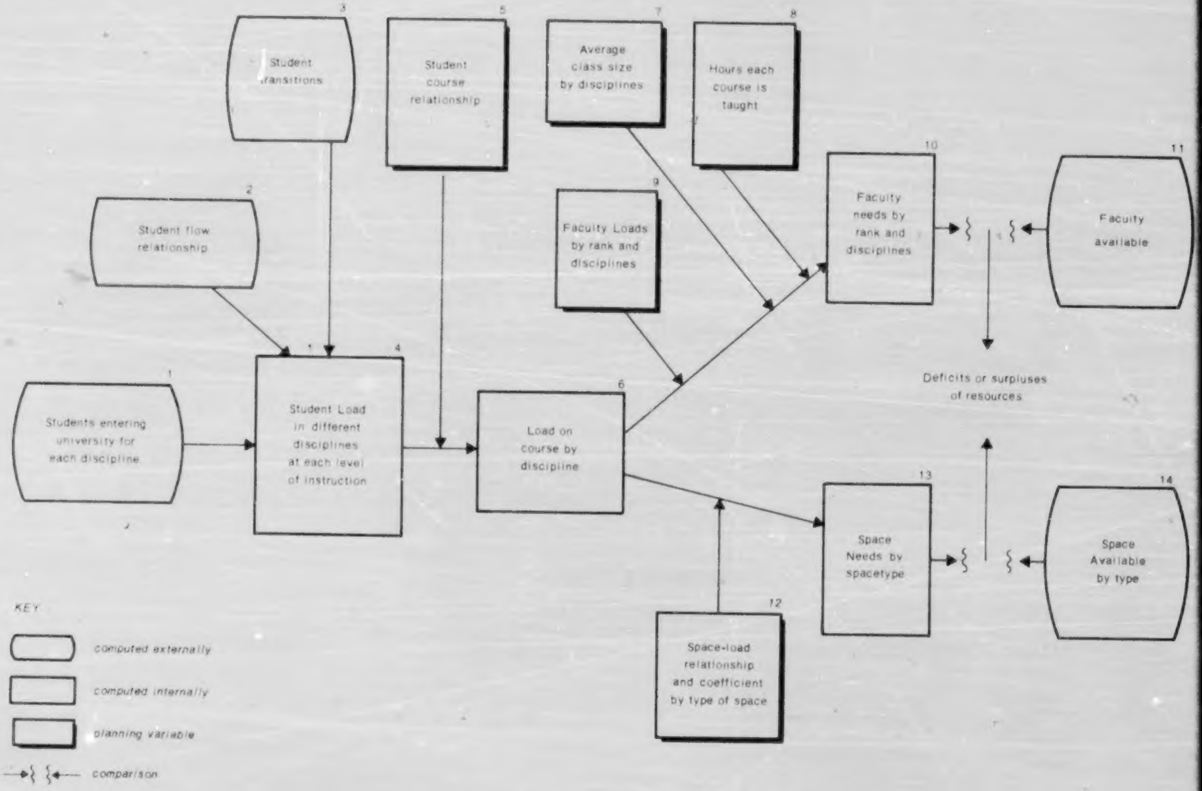
Space-load relationship

The other main inputs are the existing capacities that are constrained in the short run. These capacities are for staff and space. These are needed in calculating the incremental resources needed for a set of planning variables (incremental capacities = total capacities (calculated by model) less existing capacities).

The incremental resources needed are calculated for either one term, one year, or up to 8 years in the future. The basic functional relationship (also sometimes referred to as the basic logic of the model) is shown in Figure 3.4.

Figure 3.4

BASIC LOGIC OF HIS-A AND B


1
Students entering university for each discipline
2
Student flow relationship
3
Student transitions
4
Student Load in different disciplines at each level of instruction
5
Student course relationship
6
Load on course by discipline
7
Average class size by disciplines
8
Hours each course is taught
9
Faculty Loads by rank and disciplines
10
Faculty needs by rank and disciplines
11
Faculty available
12
Space-load relationship and coefficient by type of space
13
Space Needs by spacetype
14
Space Available by type
Deficits or surpluses of resources
KEY
computed externally
computed internally
planning variable
comparison

We start with new first-time student enrollment by discipline to the institution (box 1). This is usually predicted externally, either by the institution or the land (state) or the federal republic. In some disciplines, this is limited by institutional capacities calculated according to rules set by law (Rotter 1973). Given this value, we need to determine the students in each discipline at each level of instruction (box 4). This is done by using Student Flow relationships (box 2) and transitional values (box 3) - sometimes referred to as a Student Flow Module.

The student flow is calculated for 14 periods using one aggregate transition rate as shown in Figure 3.5. The different components of the aggregated transition are listed in Figure 3.6. Its aggregation does not allow any individual component to be used as a planning variable (as is true of RRPM and CAMPUS) but the aggregation has two advantages: one, it is easier to calculate (Erlangen University has a computer program for its calculation); and two, it is more stable.

Knowing the student load (box 4), we multiply it with the student-course relationship (also known as the Induced Course Load Matrix (box 5) to give us the course load (students taking each course) (box 6).

The course loading (in number of students for each course) (box 6) divided by the average section size for each course (box 7) gives the number of sections. This multiplied by the weekly hours to be taught for each section (box 8) gives the weekly hour load to be taught. This divided by the faculty load by rank (in weekly teaching hours or weighted hours for all academic duties) gives the faculty required by rank (box 10). This need when compared with existing faculty (box 11) gives the deficit or surplus required for the discipline examined.

The space needs (box 13) are calculated using the loading on courses (box 6) with a space-course load relationship (box 12). These needs when compared with available space by type (box 14) give the space deficits and surpluses by type and space (such as classroom and laboratory space).

3. DIFFERENCES BETWEEN VERSIONS A AND B

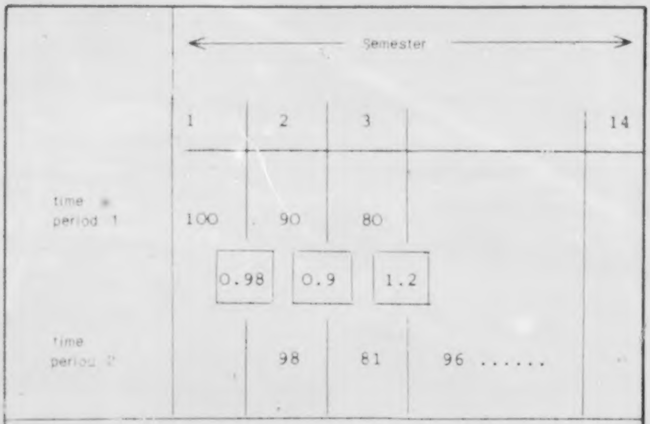
The differences in versions A and B and the order in which they will be discussed are as follows:

Computational differences

3.1 Faculty Assignment
3.2 Room Assignment
3.3 Faculty work load weighting
3.4 Capacity module

Figure 3.5

PREDICTION OF ENROLLMENT USING AGGREGATED TRANSITION RATES


Semester
1
2
3
14
time period 1
100
90
80
0.98
0.9
1.2
time period 2
98
81
96 ......

For the above example
transitions for period 1
between semester 1 and 2 = 0,98
2 and 3 = 0,9
3 and 4 = 1,2

Figure 3.6

COMPONENTS OF AGGREGATED STUDENT TRANSITION RATE

Transition rate includes

- new entrants
- movement between majors
- academic failure
- personal reasons
- all other reasons for exit.

Output

3.5 Range of outputs
3.6 Levels of aggregation.

3.1. Faculty Assignment Module

In version B (as with other models like RRPM and CAMPUS) the faculty needed is calculated by dividing the faculty hours needed by the average faculty load. In version A no such calculation is used; instead the existing faculty is assigned to the courses that need to be taught according to the ability (or preference) of faculty to teach each course (within the restriction given by each faculty load). The deficits and surpluses of faculty are then identified in terms of each course(1). This solution is lost in version B (as well as RRPM and CAMPUS) because the average faculty load for the discipline assumes a substitutability of faculty between courses within a discipline. In a discipline with few courses or faculty with a wide range of teaching abilities, this may be an acceptable assumption, but in many disciplines this is not the case and hence inaccuracies occur. As an example consider the situation where one faculty is required (a deficit) to teach European History and a surplus of one faculty, Asian History. In HIS-A the deficit and surplus is identified; in HIS-B (also in RRPM and CAMPUS), there is no net deficit or surplus for the History Discipline since they balance out in the averaging.

In spite of the unique capability of the faculty assignment module, it was dropped in HIS-B. This was largely to make the model simpler computationally as well as for making it simpler for data collection.

3.2. Room Assignment Module

In most resource models (HIS-B, RRPM and CAMPUS), the rooms required are calculated by using average section sizes. In HIS-A, a room assignment algorithm is used. This assigns courses that need to be taught to rooms already available. The deficits and surpluses by types of rooms are then identified.

The Room Assignment Module was dropped in version B, largely because another module (an optimum room assignment module) is being developed by HIS.

---

1) For details of this faculty assignment module, see Dettweiler and Frey (1972 a).

3.3. Faculty Loading

In HIS-A, the faculty loads used are teaching loads. This has been extended in HIS-B, where faculty load includes not only teaching (net) but also non-teaching duties (gross) such as class preparation, exam preparation, advising students, conducting exams, supervision of dissertations, etc. Furthermore, the duties are weighted in version B for considerations such as type of presentation (lecture, seminar, etc.); number of sections per course or preparation; thesis or dissertations, etc. One formula used for weighting is shown in Figure 3.7.

Figure 3.7

FORMULA FOR TEACHING LOAD

$$\text{Teaching Load} = \sum_{i=1}^{3} a_i w^s + b_i \frac{H}{G} w^s + c_i H$$

a = preparation factor
b = teaching factor (multiple sections)
c = personal factor (lab., thesis, seminar)
w = Student Contact Hour/Year
H = Students in class
G = Size of class

The faculty loading is calculated for 46 different structural configurations of different types of personnel required for teaching. One such structure (for Physics) is shown in Figure 3.8. At each level of this structure we need section sizes, weights and loads. This makes the faculty loading computation in HIS the most complex of all resource models.

3.4. Capacity Module

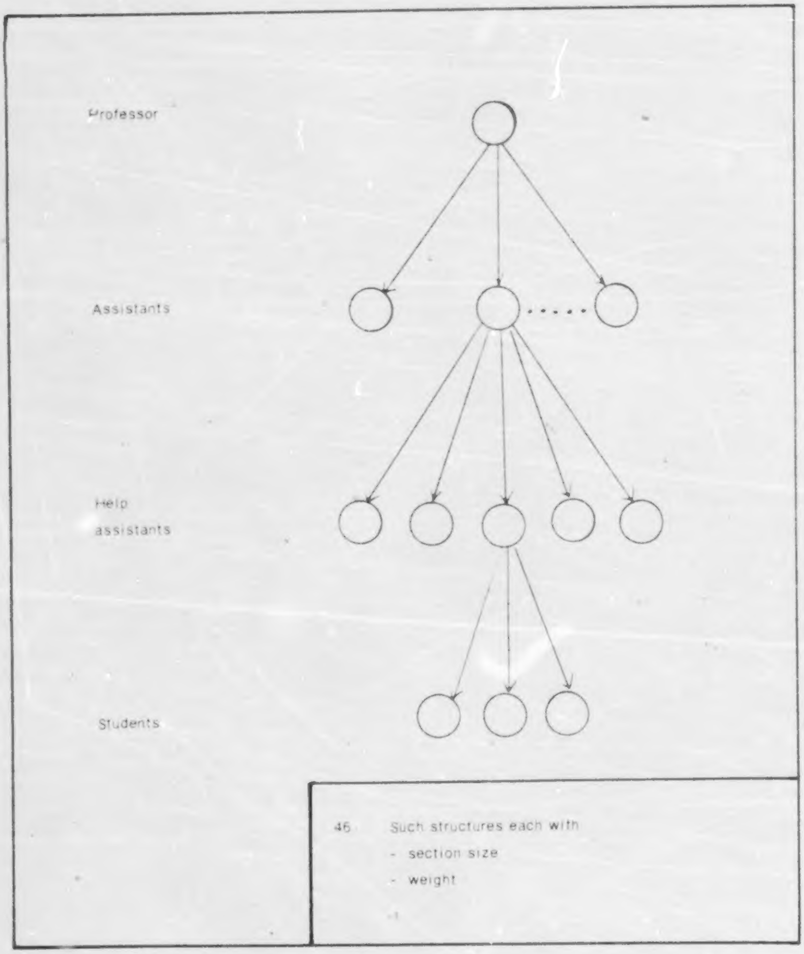
All resource models determine the resource requirements given a student enrollment. In addition, HIS-A is concerned with the reverse question: What student enrollment is possible given resource capacities. This question is important in the Federal Republic of Germany, because in many disciplines there is a nationwide shortage of capacity and it is therefore desirable to know what student numbers can be accommodated by each institution for these disciplines in which resources are constrained.

The logic of the capacity module in version A is shown in Figure 3.9, identifying its relationship to the basic logic as shown and discussed in Figure 3.4.

The main input to the capacity module are the calculations up to and including the determination of the faculty needs (box 10 in

Figure 3.8

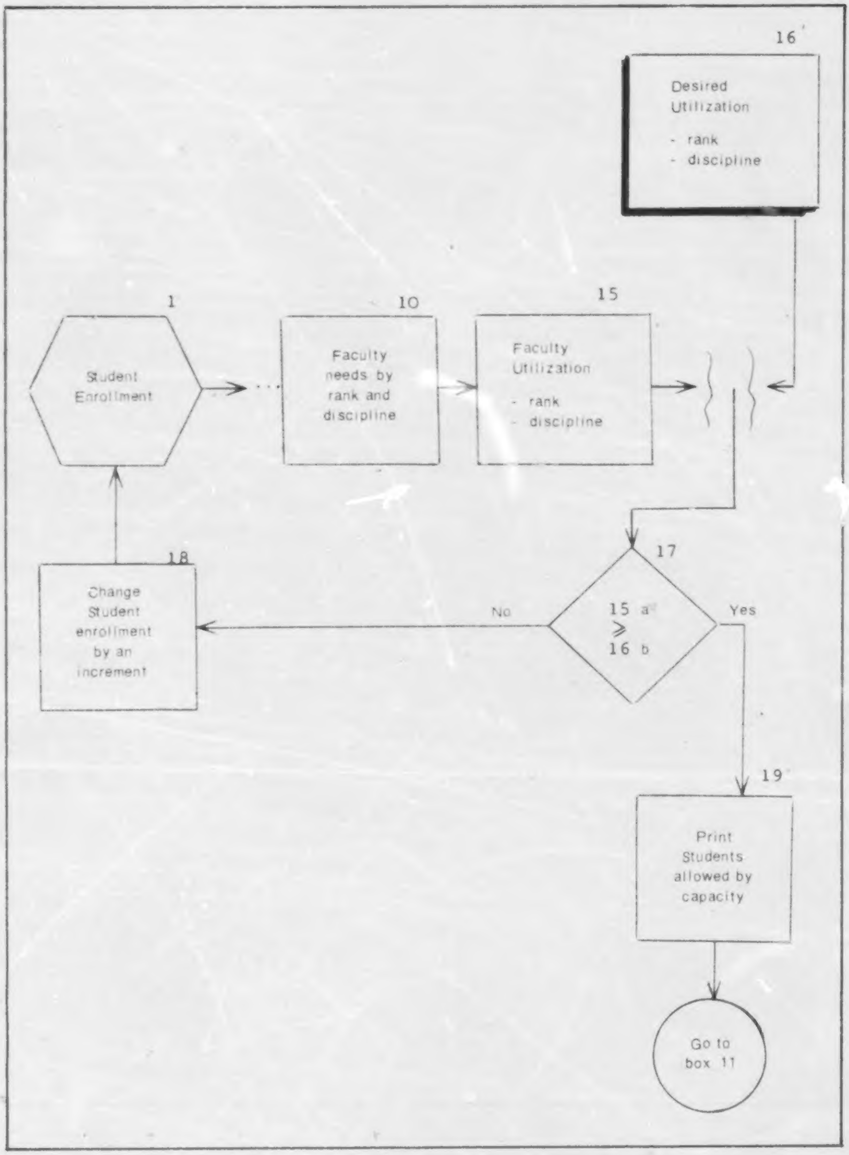
TYPICAL COURSE STRUCTURE


Professor
Assistants
Help assistants
Students

46 Such structures each with
- section size
- weight

Figure 3.9

CAPACITY MODULE IN HIS-A


16
Desired Utilization
- rank
- discipline
1
Student Enrollment
10
Faculty needs by rank and discipline
15
Faculty Utilization
- rank
- discipline
17
15 a ⩾ 16 b
No
Yes
18
Change Student enrollment by an increment
19
Print Students allowed by capacity
Go to box 11

Figures 3.4 and 3.9). These calculations are used to calculate existing resource utilizations (box 15 in Figure 3.9) and compared (box 17) with the desired utilization which is a planning variable (box 16). If the actual utilization is NOT greater than or equal to the desired utilization, then the No exit of box 17 leads to an increase in the student enrollment (box 18). This value then recycles through the basic computations (shown in Figure 3.4) and is again compared in box 17. This iteration recycling continues till the actual utilization is equal or greater than the desired utilization, then the YES exit of box 17 prints the student number that existing capacity can accommodate (box 19). The flow then continues to the next step in the basic computation (box 11 in Figure 3.4) and the capacity module is terminated.

3.5. Output

In terms of content, HIS-A has more output because it has various administrative indices of performance. These have not been included in HIS-B and will evolve after HIS-B is implemented and used. HIS-B, however, has more output in terms of levels of aggregation.

3.6. Levels of aggregation

In addition to the computations of one discipline in the college of Arts done in HIS-A, the computations are done in HIS-B for all disciplines in the college of Arts and other colleges. These computations are then aggregated for departments, colleges and the university. One example of the levels of aggregations is shown in Figure 3.10.

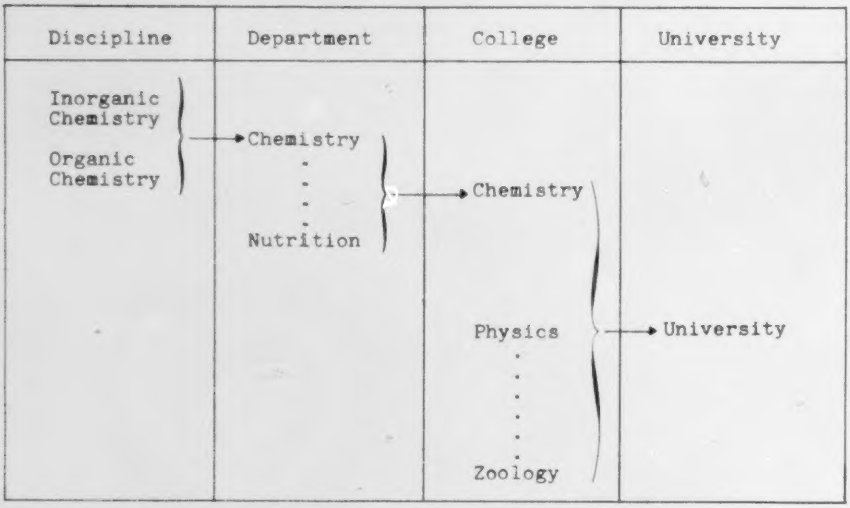
Such aggregation enables the resource model to be used at all levels of resource utilization as well as all levels of decision-making on resource allocation.

The logic flow of the aggregation is merely a repetition of boxes 10, 11 and the comparison shown in Figure 3.4. This addition and extension is shown in Figure 3.11. In it, the computations done for the discipline level (box 10 in Figures 3.4 and 3.11) are aggregated to the department level (box 20) and compared with departmental faculty available (box 21); then again aggregated for each college faculty and compared with the college inventory (box 23); and finally, all colleges are aggregated for the university (box 24) and compared to the university inventory (box 25). In each case of aggregation reports are printed (box 25-28) for the following:

1. Deficits and surpluses
2. Cross-loads
    - . Unweighted net
    - . Weighted net
    - . Weighted gross

Figure 3.10

LEVEL OF AGGREGATION OF OUTPUT


Discipline
Department
College
University
Inorganic Chemistry
Organic Chemistry
Chemistry
Nutrition
Chemistry
Physics
Zoology
University

The cross-loads are the student loads (by degree) induced between units of aggregation. These units may be disciplines, departments or colleges. This index of cross-load is an important instrument of analysis for university planning in the Federal Republic of Germany.

In discussing the differences in output between HIS-A and HIS-B mention should be made of many reports available in both versions. These are listed in Figure 3.12.

This concludes the discussion on HIS-version A and B. It is now the time to critically evaluate the model.

4. CRITIQUE OF THE HIS MODEL

The critique will be in three parts. One will be concerned with limitation of all resource models; two will identify the unique strong points of the HIS model; and, finally, part three will discuss the limitation of the HIS model.

Limitations of all resource models (including CAMPUS, RRPM and TUSS) are that they are not optimizing models (except for sub-optimization such as the Faculty Assignment model in HIS-A). Also, they are largely not concerned with contract-research (except TUSS to a limited extent) nor with the medical faculty (except CAMPUS-HEALTH). Also they do not consider benefits or performance; the quality

Figure 3.11

AGGREGATION IN HIS-B

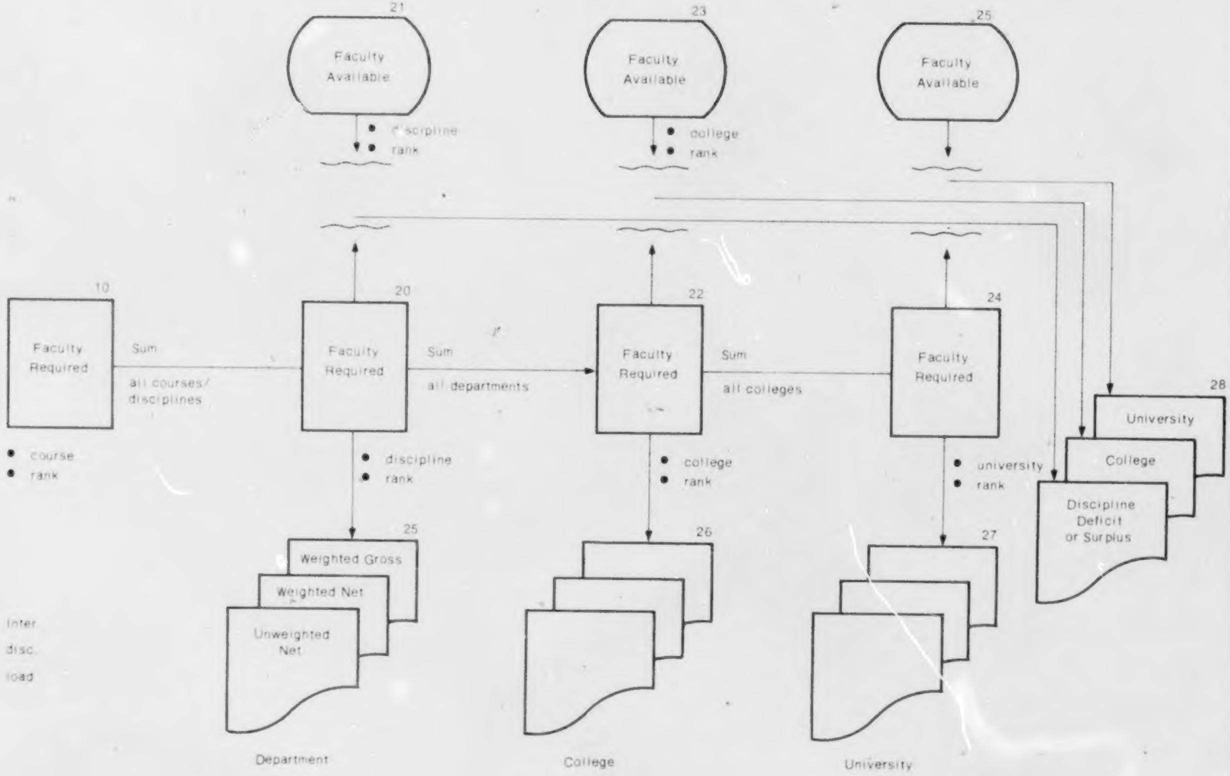

21
Faculty Available
• discipline
• rank
23
Faculty Available
• college
• rank
25
Faculty Available
10
Faculty Required
Sum
all courses/ disciplines
• course
• rank
20
Faculty Required
Sum
all departments
• discipline
• rank
22
Faculty Required
Sum
all colleges
• college
• rank
24
Faculty Required
• university
• rank
25
Weighted Gross
Weighted Net
Unweighted Net
Department
26
College
27
University
28
University
College
Discipline Deficit or Surplus
Inter
disc.
load

Figure 3.12

SUPPLEMENTARY OUTPUT FOR HIS-A/B

Showing combinations of variables

- Faculty
- Departments
- Colleges/Schools
- Student Courses
- Rank of faculty
- Load of
  - faculty
  - students
  - courses
- Room utilization
  - by type
- Classes
  - by type
- Time factors
  - net teaching
  - gross teaching

of the student, teacher or courses, nor the relevance of the programs offered or their demand by society.

HIS-version A and B do not have a faculty flow module (as does CAMPUS). However, it does do its computations at the course level (as does CAMPUS and TUSS but unlike RRPM).

The main output is the resource implications of a set of planning variables. No help, however, is given in selecting the planning variables or searching from among the alternatives being simulated.

This simulation is done in batch rather than through a terminal (except CAMPUS-CONNECT) and the results are mostly tables rather than plotted curves. There is no possibility to generate directly the trade-offs between two variables simulated. The data is in the output tables and must be extracted manually.

In spite of these general limitations, the HIS-model is useful because it has many unique features. These include the room algorithm, the faculty optimal assignment module, the capacity module and its weighting of faculty load in a variety of complex teaching structures.

There are also some unique limitations of the HIS-model: It is limited to the teaching sector and even there it calculates only resources, not costs or unit costs (as does CAMPUS and RRPM).

Furthermore, it has limited experience in its implementation, each version having been implemented in one institution each(1). The

---

1) Some further implementations have been started.

main obstacle to wider implementation is not conceptual but rather the lack of a computerized data base. This limitation as well as the other unique limitations discussed above will be relaxed in the future version of the HIS, a subject we will now discuss.

5. FUTURE DEVELOPMENT OF THE HIS MODEL

For the purpose of this paper, we shall label the next operational version of the HIS model as HIS-C, version C of HIS. As currently planned, it will be interfaced with the many related projects currently being implemented as part of the HIS activities. These are shown diagramatically in Figure 3.13.

A group of future projects are concerned with data - its generation, its integration and its compatibility. One of these is concerned with creating a data base through a set of functional files (box 1 in Figure 3.13). These are developed largely at the HIS headquarters in Hanover and implemented at different universities in the Federal Republic of Germany. These files will then be integrated horizontally. One approach would be the use of a Data-Base-computer package such as IMS. This is currently being implemented at three institutions in Dortmund (box 2). Related to data integration is the problem of having a Data Element Dictionary (box 3) and a Program Classification Structure (box 4). Its national adoption will enable integration of data at all levels of decision-making from institutions up to the federal agencies and also facilitate information exchange between institutions. Such integration of data will also enable better exploitation of the basic data and enable its use at all levels of decision-making within an institution - i.e. by operational, control and planning managers and administrators.

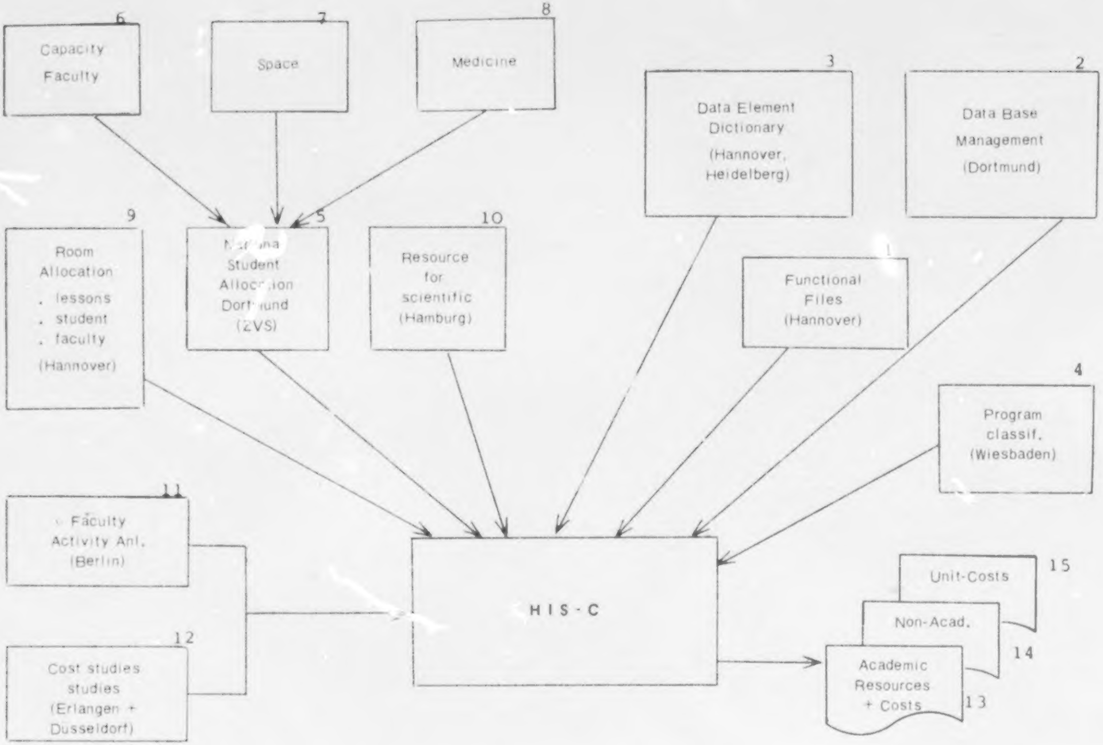
Another set of projects concerns the allocation of new students done nationally by a federal agency at Dortmund. This Model (Böckling, 1973) (box 5) requires the determination of capacities. These capacity models are separate for faculty (box 6), space (box 7) and for the medicine faculties (box 8).

Another model (referred to earlier under 3.2) (box 9 in Figure 3.13) is concerned with room allocations of courses, students and faculty. This model will then be used in HIS-C for allocating existing rooms as required by the model and then calculating resulting deficits and surpluses of rooms.

There is also a Resource Requirement study being conducted at Hamburg and is concerned with all resources required for the scientific faculties (box 10). This will help in extending the scope of HIS-A/B to non-teaching sectors (report sets 13 and 14).

Figure 3.13

FUTURE PLANS FOR HIS-C


6
Capacity
Faculty
7
Space
8
Medicine
3
Data Element
Dictionary
(Hannover,
Heidelberg)
2
Data Base
Management
(Dortmund)
9
Room
Allocation
. lessons
. student
. faculty
(Hannover)
5
National
Student
Allocation
Dortmund
(ZVS)
10
Resource
for
scientific
(Hamburg)
1
Functional
Files
(Hannover)
4
Program
classif.
(Wiesbaden)
11
Faculty
Activity Anl.
(Berlin)
12
Cost studies
studies
(Erlangen +
Dusseldorf)
HIS-C
15
Unit-Costs
14
Non-Acad.
13
Academic
Resources
+ Costs

Finally, there are the projects related to costs and costing. One project is concerned with Faculty Activity Analysis being done at a college at Berlin (box 11). Another are two projects related to costs and costing at Erlangen and Düsseldorf (box 12). These studies will contribute to the extension of the scope of HIS output to report not just resources but also their costs (Report set 13) and their unit costs (Report set 15).

6. SUMMARY

The HIS models are simulation models that calculate the resource (teaching staff and space) for instructional activities for a set of planning factors for an institution of higher education.

There are two versions of HIS, A and B. Their major differences are listed in Figure 3.14.

Future plans for version C envisage the extension of resources considered to all resources not just space and faculty. Furthermore, these resources will be calculated for all sectors of the institution not just instruction. The resources will also be reported in monetary terms and unit costs will then be generated.

The output will also be expanded. It will contain administrative indices as well as information required for the purpose of operations and control. The data used for the model will be integrated with that used for the functional files of the university.

Figure 3.14

COMPARISON OF HIS-A AND B

	HIS-A	HIS-B
Implementation		
. when	1970	1973
. where	Heidelberg	Karlsruhe
Highest level of aggregation	Department	University
Type of instruction included	Liberal Arts	Liberal Arts and Science
Administrative indices in output	Yes	Not yet
Non-teaching academic loads included	No	Yes
Teaching duties weighted	Only for teaching	For all academic
Optimal teacher assignment module	Yes	No
Room assignment algorithm	Yes	No
Capacity module	Yes	Not yet

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Chapter 4

THE MSAR MODEL

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1. INTRODUCTION

MSAR stands for the Model of Simulation and Allocation of Resources. Its need and evolution, its basic logic and its implementation is the subject of this paper.

2. EVOLUTION OF MSAR

In 1973 the Government of Portugal decided to found a new university to be located in the environs of Lisbon. It was to be called the Universidade Nova de Lisboa. A rector was appointed with a staff for planning and organizing the university. They were to expect an enrollment of 800 students in 1976 and 10,000 students in 1985.

An early decision made was that the new planned university could be different from the traditional universities in Portugal. Different not only in curricula mix and techniques of instruction but different also in the mix of services offered to the students and the design of those services. However, the curricula and services had to be designed within budgetary constraints. It required calculating the resource implications of each set of alternatives to test them for financial feasibility. This suggested the need of a resource prediction model. But to be useful in making planning trade-offs, it was necessary to have a model with the capability of simulating different sets of alternatives and answer "what-if" type questions for the planner.

At the time, there were numerous simulation models being used in higher education, both in the U.S. and in Europe. Some of these were studied in detail. These included RRPM and CAMPUS from the U.S., as well as HIS and TUSS from Europe. It was determined that the basic computations in these models for determining the salaries were largely compatible with the philosophy of the planners of Universidade Nova. The existing models could therefore be adapted with some modifications, especially in the area of faculty loading that seemed unique to Portugal. However, the model had to be extended by additional submodels that could be used independently for suboptimization and planning as well as used in conjunction with the institutional resource budgeting model. Two such submodels were identified. One was for space planning that would simulate different mixes of space types given different planning factors such as space used for student or staff, construction cost coefficients, multiple use of space, etc.

74

Another submodel was to simulate different mixes of personnel given different planning factors such as faculty loading, staff loading, teaching techniques, class sizes, instruction types, etc. These submodels were responsible for the conjunction "and" in the name of the model "Model for Simulation and Allocation of Resources". It was thus not merely a model for allocating resources but also for simulating different resource configurations. Also, the planning group at the Universidade Nova stipulated that the data needs of the planning model were to be integrated with the data needs of operation and daily management. Given these design specifications, the model construction of the MSAR model began in late 1973. Its basic logic is discussed below.

3. BASIC LOGIC OF THE MSAR MODEL

3.1. Overview

An overview of the basic MSAR model is shown in Figure 4.1. In it are shown the main components of the computations with each computation being elaborated in a separate figure later(1).

The first computation is that of hours to be taught (box 2)(2). This is the basis of calculations for the staff required and hours required for teaching (box 3); for non-teaching but still instructional such as instructional administrators and secretarial staff (box 4); and for maintenance staff such as caretakers and cleaning staff (box 5). These calculations of staff required (boxes 3, 4 and 5) are input needed for calculating salary costs (box 6). Finally, there is the cost of new space (box 7). This is also a function of the different types of staff required (boxes 3, 4 and 5).

3.2. Calculation of Hours to be Taught

The calculation of hours to be taught (box 2) is shown in detail in Figure 4.2. It starts with the number of students in each major and in each academic level of study(3) (box 9) which is also determined in the institution being predicted by the national agency

---

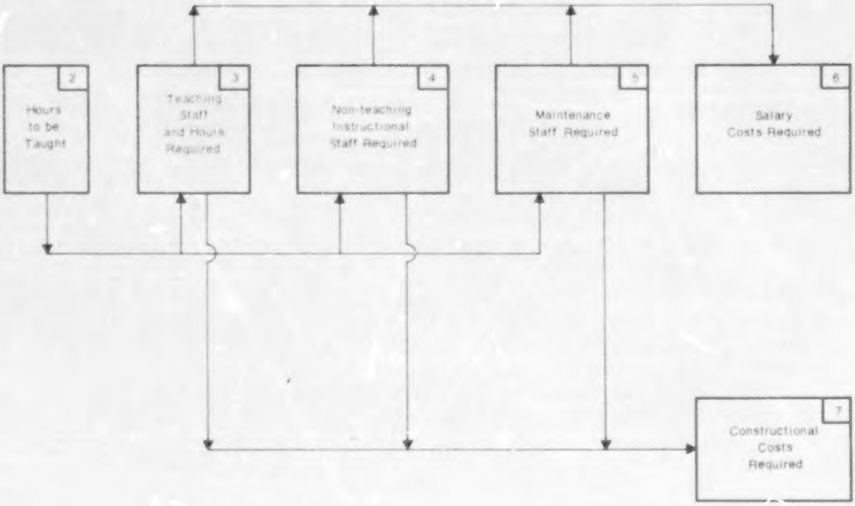
1) The figure number corresponds to the number of the box in Figure 4.1.

2) There is no box 1 because there is no detailed figure that corresponds to Figure 4.1.

3) The dimensions of the planning variable are identified in the diagram. In the future, such dimensions will not be mentioned in the text, unless it is important to the discussion. Also, all planning variables are identified (in all the figures in this paper) by a special symbol. Henceforth, they will not always be so identified in the text.

Figure 4.1

OVERVIEW OF THE LOGIC OF MSAR

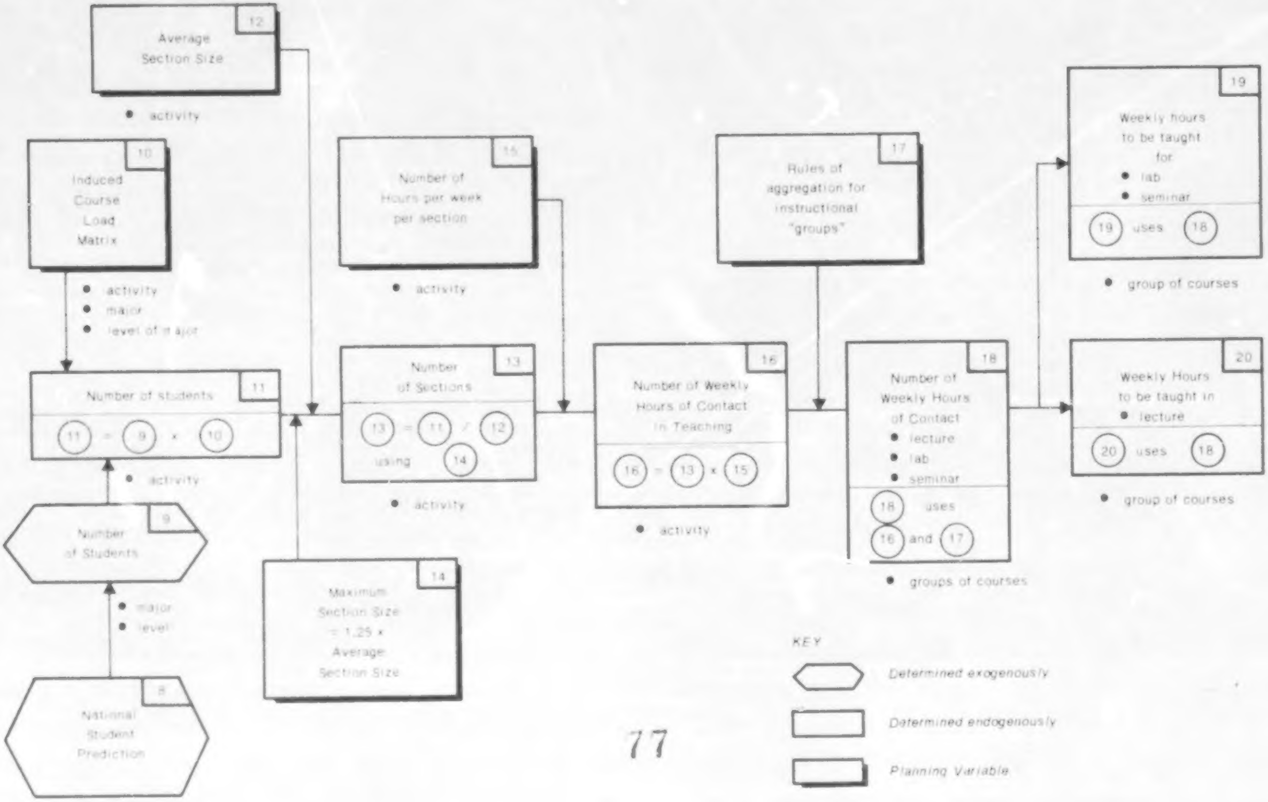

2
Hours to be Taught
3
Teaching Staff and Hours Required
4
Non-teaching Instructional Staff Required
5
Maintenance Staff Required
6
Salary Costs Required
7
Constructional Costs Required

(box 8) and then the number of students (also external to the model). In most models, this is done by a student flow model or a set of regression equations. In the case of the Universidade Nova, there is no historical data for use in regression equations or flow models. Instead, the student enrollments are predicted on a national basis and according to the calendar of implementation of the different majors at the Universidade Nova. The flow of the students after the enrollment will be calculated by a student flow model which is being developed.

The ICLM (box 10) identifies the course load induced (generated) by students in different majors for different activities, an activity being either a course or a subset of a course (i.e. a lab or a seminar) that requires a unique set of personnel and space resources. The ICLM is a policy variable (subject to the curriculum structure and some student choice (box 10) and its product with the number of students in each major and each level (box 9) gives the number of students in each activity (box 11). This number divided by the planning variable of average section size (for each activity which specifies each type of instruction) (box 12) gives the number of sections (box 13). In cases where a few students are left over after distribution by the average section size, the section size can be increased to the maximum section size (which is the same ratio for all sections) (box 14) or else an additional section is added.

Figure 4.2

CALCULATION OF HOURS TO BE TAUGHT



12 Average Section Size
• activity
10 Induced Course Load Matrix
• activity
• major
• level of major
11 Number of students
(11) = (9) x (10)
• activity
9 Number of Students
• major
• level
8 National Student Prediction
15 Number of Hours per week per section
• activity
13 Number of Sections
(13) = (11) / (12) using (14)
• activity
14 Maximum Section Size = 1.25 x Average Section Size
16 Number of Weekly Hours of Contact in Teaching
(16) = (13) x (15)
• activity
17 Rules of aggregation for instructional "groups"
18 Number of Weekly Hours of Contact
• lecture
• lab
• seminar
(18) uses (16) and (17)
• groups of courses
19 Weekly hours to be taught for
• lab
• seminar
(19) uses (18)
• group of courses
20 Weekly Hours to be taught in
• lecture
(20) uses (18)
• group of courses
KEY
Determined exogenously
Determined endogenously
Planning Variable

The number of sections is calculated for each type of instruction such as lecture, laboratory or seminar: the identification of the type of instruction is implicit in the data on each activity.

The number of sections (box 13) when multiplied by the number of hours per week that the section meets (box 15) gives the number of weekly contact-hours of teaching. This is calculated for each activity (box 16). These weekly hours are then aggregated and combined with groups of activities or courses such that they are homogeneous for purposes of common instruction. For example, piano and flute are aggregated into one group because they are homogeneous for teaching purposes and for calculating teaching resources. Such group aggregation rules (box 17) applied to the weekly contact-hours of teaching (box 16) gives the total number of weekly contact for each group and type of instruction (box 18). This number is then rearranged to correspond to patterns of faculty loading and teaching staff salary structure. This divides the number of weekly contact-hours into a category for labs (laboratories) and seminars (box 19) and separates them from the lectures (box 20). The calculation of faculty in each of the two categories is discussed in Figure 4.3, the next set of calculations.

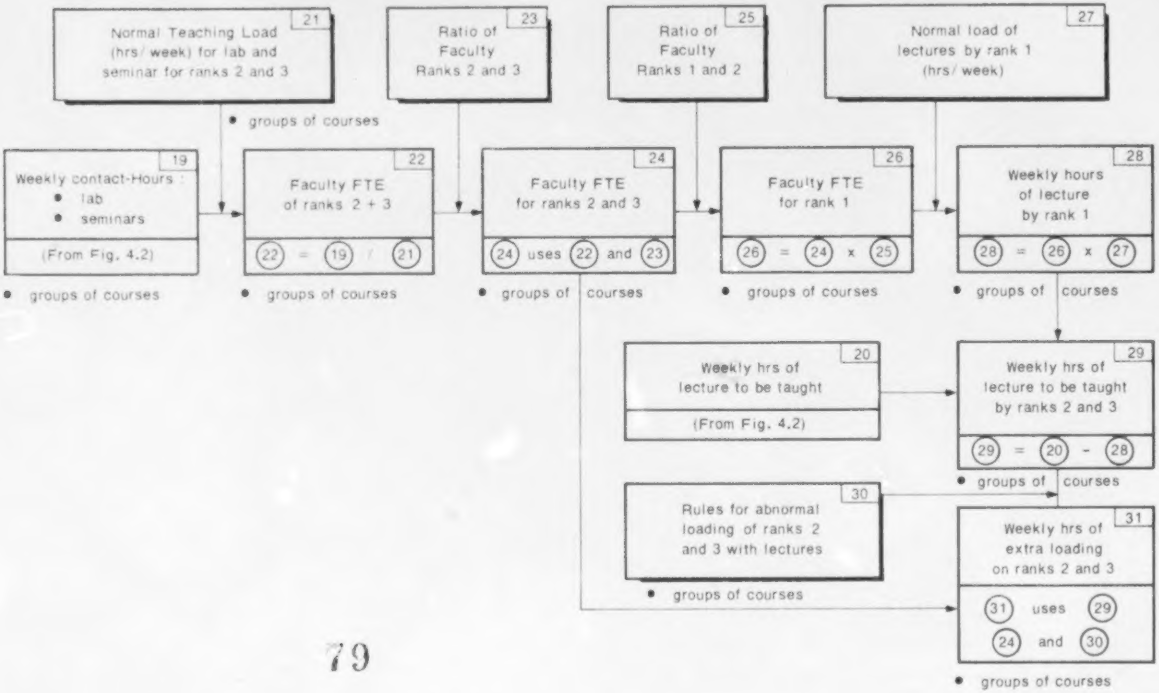
3.3. Calculation of faculty

The calculation of faculty in MSAR is different from other models, largely because MSAR allows overtime which is paid for as overtime for certain ranks (ranks 2 and 3) while the mix of ranks is fixed by ratios that are policy variables. Furthermore, only certain ranks teach labs and seminars (ranks 2 and 3). This is the starting point of the faculty calculations. The weekly hours required of labs and seminars (calculated previously in the model) is divided by the load of ranks 2 and 3 to give the FTE for ranks 2 and 3. This then gives the FTE for rank 1 by using the rank mix ratio. The rank 1 teach only lectures and their given load determines the weekly hours they can teach. This is subtracted from the weekly hours of lectures to be taught (calculated previously in the model) to determine the remaining weekly hours of lectures yet to be taught. This is taught by rank 2 and 3 on overtime. This calculation is used later for calculating salaries and is discussed along with Figure 4.6.

The detailed calculations are shown in Figure 4.3. The labs and seminars are taught by faculty in ranks 2 and 3 (the only faculty ranks below the professorial level of rank 1). Hence, the weekly hours to be taught in labs and seminars (box 19, Figure 4.3) is divided by the normal load (one that is done without overtime) for ranks 2 plus 3 (policy variable, box 21) to give the FTE required for ranks 2 and 3 (box 22). This varies with each group of courses (almost equivalent to disciplines in the American sense).

Figure 4.3

CALCULATION OF FTE AND HOURS REQUIRED FOR TEACHING


21
Normal Teaching Load (hrs/week) for lab and seminar for ranks 2 and 3
23
Ratio of Faculty Ranks 2 and 3
25
Ratio of Faculty Ranks 1 and 2
27
Normal load of lectures by rank 1 (hrs/week)
• groups of courses
19
Weekly contact-Hours :
• lab
• seminars
(From Fig. 4.2)
• groups of courses
22
Faculty FTE of ranks 2 + 3
(22) = (19) / (21)
• groups of courses
24
Faculty FTE for ranks 2 and 3
(24) uses (22) and (23)
• groups of courses
26
Faculty FTE for rank 1
(26) = (24) x (25)
• groups of courses
28
Weekly hours of lecture by rank 1
(28) = (26) x (27)
• groups of courses
20
Weekly hrs of lecture to be taught
(From Fig. 4.2)
29
Weekly hrs of lecture to be taught by ranks 2 and 3
(29) = (20) - (28)
• groups of courses
30
Rules for abnormal loading of ranks 2 and 3 with lectures
• groups of courses
31
Weekly hrs of extra loading on ranks 2 and 3
(31) uses (29) (24) and (30)
• groups of courses

The FTE for ranks 2 plus 3 (box 22) is disaggregated in rank 2 and rank 3 separately (box 24) by using the policy variable of the ratio of rank 2 and rank 3 (policy variable, box 23). The FTE for rank 2 is used and multiplied by the ratio or rank 1 to 2 (policy variable, box 25) to give the FTE for rank 1 (box 26). This FTE, when multiplied by the normal load for rank 1 in terms of weekly hours of lectures (policy variable, box 27, which is negotiated or presented), gives the weekly hours of lectures taught by rank 1 (box 28). This is subtracted from the weekly hours of lectures that must be taught and calculated as shown in Figure 4.2 (box 20), giving the weekly hours of lectures not taught by rank 1 (box 29). These hours are then distributed between ranks 2 and 3 according to overload rules (policy variable, box 30). All these FTE calculations are done for each group of courses or disciplines.

3.4. Calculation of Non-Teaching Instructional Staff

The calculations for non-teaching staff in instructional departments are shown in Figure 4.4. The first computation is the calculation of the weekly hours of non-teaching instructional staff (box 33). This is stated as a function of the weekly contact hours of teaching (box 16) and the number of students (box 9). These two values are multiplied by the relevant coefficient of non-teaching weekly hours to teaching hours and students in each activity and type of staff (box 32) gives the weekly hours of non-teaching instructional staff (box 33) by type of staff and activity. These hours when divided by the FTE load for each staff type (i.e. weekly hours worked by each FTE) (box 34) gives the FTE required for non-teaching instructional staff (box 35). This calculation is done by departments (academic administrative unit) using the relationship of activities to departments as a policy variable (box 35).

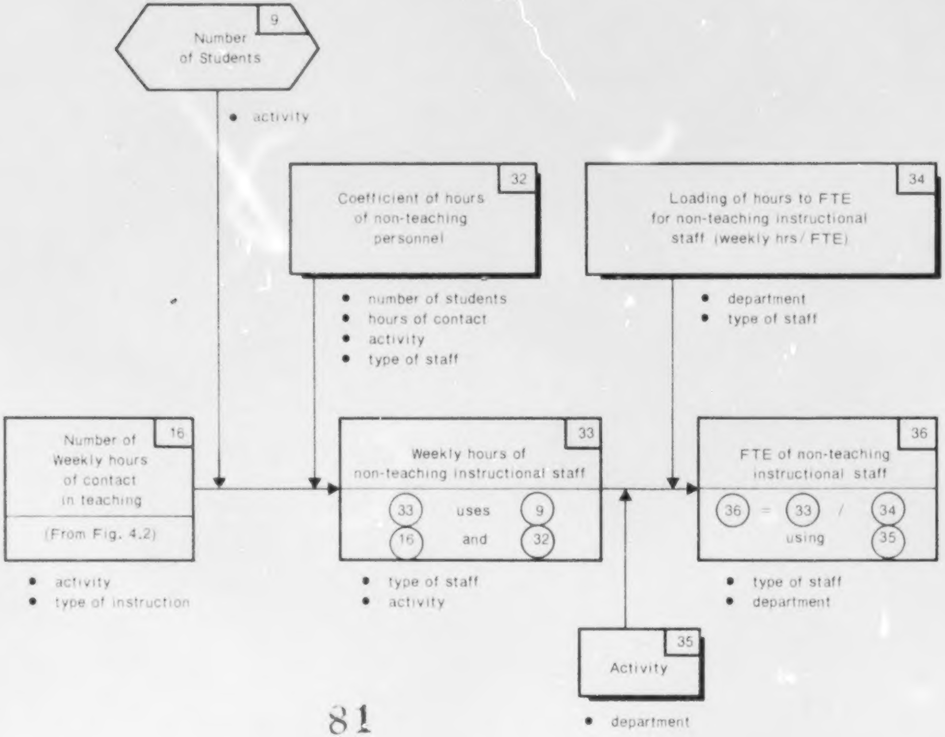
Eventually, one type will be defined as lab assistants for each discipline. The problem, of course, is to determine the coefficients of lab assistants required per student and/or per contact hour for each discipline. This calculation has not been done by any of the other allocation models and so there is little empirical data that can be used operationally. It must be calculated or estimated. It is expected that this will be done in a later phase of the development of MSAR.

3.5. Calculation of Maintenance Staff

Maintenance staff is defined in the MSAR model as being all personnel concerned with the upkeep and maintenance of physical non-movable property. This includes buildings and grounds.

Figure 4.4

CALCULATION OF NON-TEACHING INSTRUCTIONAL STAFF REQUIRED


9
Number of Students
● activity
32
Coefficient of hours of non-teaching personnel
● number of students
● hours of contact
● activity
● type of staff
34
Loading of hours to FTE for non-teaching instructional staff (weekly hrs/ FTE)
● department
● type of staff
16
Number of Weekly hours of contact in teaching
(From Fig. 4.2)
● activity
● type of instruction
33
Weekly hours of non-teaching instructional staff
33 uses 9
16 and 32
● type of staff
● activity
36
FTE of non-teaching instructional staff
36 = 33 / 34
using 35
● type of staff
● department
35
Activity
● department

The maintenance staff calculations are shown in Figure 4.5. The first basic computation is the calculation of rooms required for teaching by size and space type (box 38). This is derived from the weekly contact-hours of teaching by activity (box 16) and converting them into room sizes with the planning variable of maximum section sizes by activity (box 14) using the desired room utilization by space type (box 36) as another planning factor. The room sizes are classified into space types by the planning variables of space types desired for each instruction type within each discipline (box 37).

The rooms required for teaching (box 38) when multiplied by a ratio of non-teaching to teaching rooms (box 39) gives the rooms required for non-teaching (box 40). This, when added to the rooms required for teaching (box 38) gives the total number of rooms required (box 41). These are rooms classified by sizes and space type and by department. There are 50 space types allowed for in the model. The space type has a 7-digit code and includes size classifications. Hence, size is not specified as a separate dimension. The weekly hours of maintenance required (box 42) is the product of the total rooms required (box 41) and the weekly hours required for maintenance for each room (box 42). The weekly hours required of maintenance staff (box 43) divided by the FTE load of maintenance staff (box 44) gives the FTE required for maintenance (box 45).

3.6. Calculation of Salaries and Staff Required.

Once the different FTE components are calculated, the salary computation follows next. This is done for the following types of staff: faculty in all ranks, teaching instructional personnel, and finally, maintenance staff. These calculations are shown in Figure 4.6 in addition to one related computation: additional staff to be hired. All these computations are briefly discussed below.

The total teaching salaries is a function of the total FTE at all ranks and each discipline (boxes 26 and 24) as well as the hours of faculty loadings (box 31) which gives the hours of overtime that must be paid for. The FTE (in ranks 1 and the group ranks 2 and 3) and the overtime are multiplied by their salary schedule for each rank and the overtime (boxes 46, 47 and 48, respectively) to yield the teaching salary costs in each case (boxes 49, 50 and 51). These salary components totalled give total salary cost for teaching (box 52).

The remaining salary components are a direct product of the FTE for each type of staff and its corresponding annual salary schedule for each type of staff. Thus, the non-teaching instructional salary (box 54) is the product of the FTE required for non-teaching instructional staff (box 36) with the salary schedule of that staff in each discipline (box 53); and the maintenance salary costs (box 56) is

Figure 4.5

CALCULATION OF MAINTENANCE STAFF REQUIRED

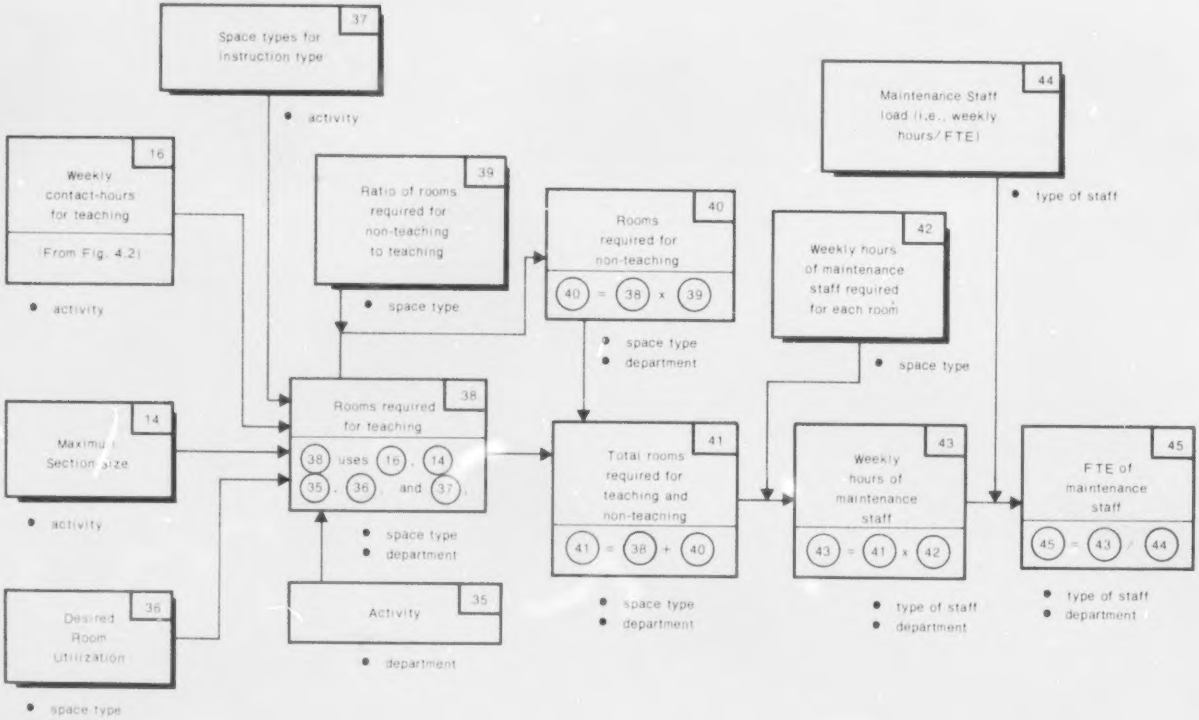
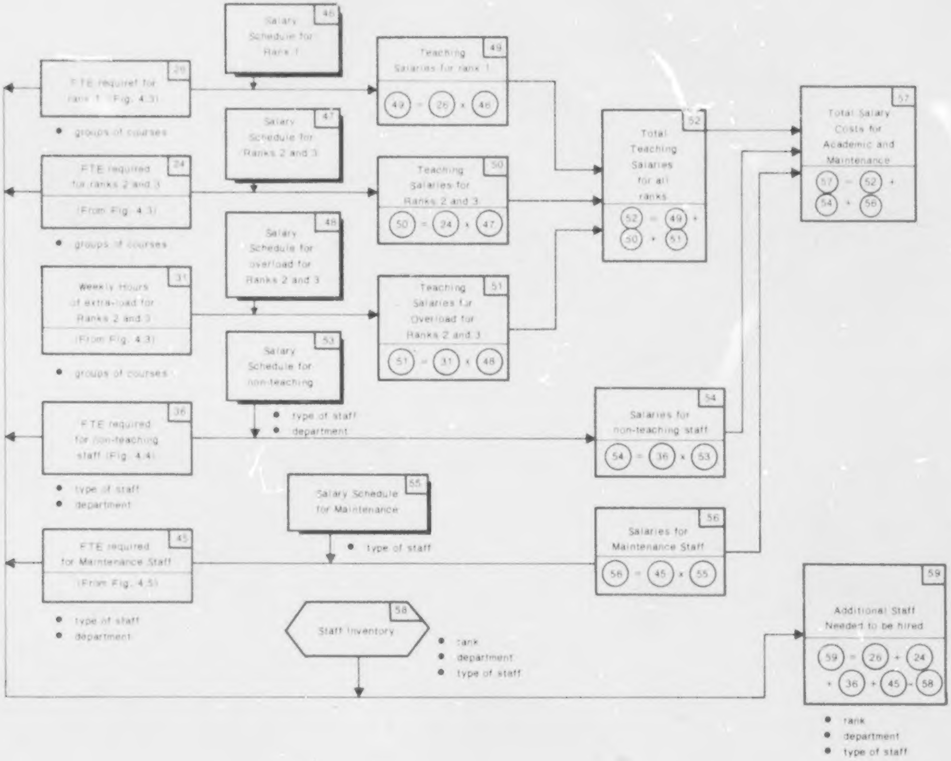

37
Space types for instruction type
• activity
16
Weekly contact-hours for teaching
(From Fig. 4.2)
• activity
39
Ratio of rooms required for non-teaching to teaching
• space type
40
Rooms required for non-teaching
40 = 38 x 39
• space type
• department
44
Maintenance Staff load (i.e., weekly hours/FTE)
• type of staff
42
Weekly hours of maintenance staff required for each room
• space type
14
Maximum Section size
• activity
38
Rooms required for teaching
38 uses 16, 14, 35, 36, and 37.
• space type
• department
41
Total rooms required for teaching and non-teaching
41 = 38 + 40
• space type
• department
43
Weekly hours of maintenance staff
43 = 41 x 42
• type of staff
• department
45
FTE of maintenance staff
45 = 43 / 44
• type of staff
• department
36
Desired Room Utilization
• space type
35
Activity
• department

Figure 4.6

CALCULATION OF SALARIES OF ADDITIONAL STAFF


46
Salary Schedule for Rank 1
26
FTE requiref for rank 1 (Fig. 4.3)
● groups of courses
49
Teaching Salaries for rank 1
(49) = (26) x (46)
47
Salary Schedule for Ranks 2 and 3
24
FTE required for ranks 2 and 3
(From Fig. 4.3)
● groups of courses
50
Teaching Salaries for Ranks 2 and 3
(50) = (24) x (47)
48
Salary Schedule for overload for Ranks 2 and 3
31
Weekly Hours of extra-load for Ranks 2 and 3
(From Fig. 4.3)
● groups of courses
51
Teaching Salaries for Overload for Ranks 2 and 3
(51) = (31) x (48)
52
Total Teaching Salaries for all ranks
(52) = (49) + (50) + (51)
57
Total Salary Costs for Academic and Maintenance
(57) = (52) + (54) + (56)
53
Salary Schedule for non-teaching
● type of staff
● department
36
FTE required for non-teaching staff (Fig. 4.4)
● type of staff
● department
54
Salaries for non-teaching staff
(54) = (36) x (53)
55
Salary Schedule for Maintenance
● type of staff
45
FTE required for Maintenance Staff
(From Fig. 4.5)
● type of staff
● department
56
Salaries for Maintenance Staff
(56) = (45) x (55)
58
Staff Inventory
● rank
● department
● type of staff
59
Additional Staff Needed to be hired
(59) = (26) + (24) + (36) + (45) - (58)
● rank
● department
● type of staff

the product of the FTE for maintenance (box 45) and its salary schedule (box 55). These salary costs components are summed along with teaching salary costs giving the total salary costs of the institutions (box 57). This is the annual costs since the salary schedules were annual.

A calculation that logically follows is to determine the additional new personnel that must be hired; i.e. the incremental (box 59). This is done by totalling the FTE required (boxes 26, 24, 36, and 45) and subtracting from it the staff positions existing in each case (which may include one who will retire but will be replaced). This data on existing staff (box 58) is determined exogenously as most likely from the personnel file.

3.7. Construction Costs

The final set of computations concerns the capital budget as distinct from the operating budget discussed above. These calculations are shown in Figure 4.7. They calculate the cost of constructing additional rooms required. The additional rooms are determined by comparing the rooms required (in any one year's resource prediction) for teaching (box 38) and those required for non-teaching (box 40) with the rooms stated exogenously on the space file (box 60). Some deficiencies can be overcome by room substitution rules (box 61) such as a lecture room of size 30 could be used for a seminar of size 20. After all substitution rules are applied, there may still remain rooms that are still needed (box 62). These requirements are multiplied by construction cost coefficients (box 63) allowing for discontinuity or step functional relations (box 64). Examples of these relationships would be a minimum number of rooms of a space type before a building is considered feasible or economical for construction. Given these constraints, the constructional costs for additional rooms are determined (box 65).

4. IMPLEMENTATION OF MSAR

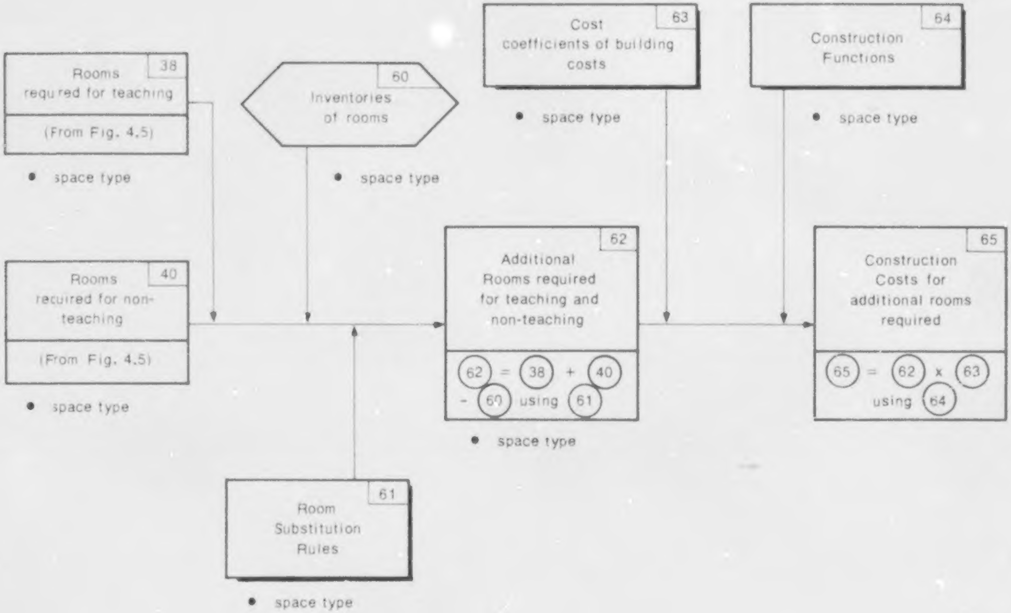
The model as described above will be implemented in 1975. It will be used cautiously in the decision-making process. It will be run to answer many "what-if" type questions.

None of the planning variables were based on historical data because there is none. In some cases, however, historical data from other institutions were used as guidance and possible range value.

Other planning variables were determined after discussions of the planning committee along with experts and consultants. Eventually, some of these variables will be influenced by historical data of the university. To ensure that this would be possible, the planning model

Figure 4.7

CALCULATION OF CONSTRUCTIONAL COSTS REQUIRED


38
Rooms required for teaching
(From Fig. 4.5)
• space type
40
Rooms required for non-teaching
(From Fig. 4.5)
• space type
60
Inventories of rooms
• space type
61
Room Substitution Rules
• space type
63
Cost coefficients of building costs
• space type
64
Construction Functions
• space type
62
Additional Rooms required for teaching and non-teaching
62 = 38 + 40 - 60 using 61
• space type
65
Construction Costs for additional rooms required
65 = 62 x 63 using 64

group spent much time in the development of the institutional information system and ensured that the data elements required by the MSAR and its projected submodels were included in the institutional Data Element Dictionary. Furthermore, many output reports used by operational management and other special reports were designed to provide the analytical information needed for future determination of planning variables for MSAR. Meanwhile, the basic part of MSAR is being further validated and extensions to the model as well as submodels are being designed and implemented.

5. EVALUATION OF MSAR

MSAR was designed and implemented in one year, a relatively short time for such comprehensive planning models. There are at least two explanations for this. One is that MSAR had top management support. The Rector had a planning background and had come directly from the National Planning Office for Education. Furthermore, he brought with him part of his planning staff that were both knowledgeable and experienced in modelling.

Another reason for MSAR's relatively quick success was that it decided not to "reinvent the wheel" as did the designers of HIS and TUSS. They adopted most of the basic concepts of existing models and hence were able to concentrate more on adaptation, extensions, and implementations.

An example of adaptation of the basic computation is the calculation of faculty salaries. It is not only a function of faculty FTE as in the CAMPUS, HIS, RRPM, and TUSS, but is also a function of overtime spent by faculty. Some unique variations include classification of size within space types.

Examples of extensions in the basic computations are the estimation equations for personnel. MSAR calculates personnel requirements not only for maintenance personnel but also specialized type of instructional personnel such as lab assistants. Making lab assistants a function of discipline, number of students, contact and type of instruction is elegant, but it raises questions about the availability, validity and benefit-cost ratio of using the estimation equations. Experience of implementors of RRPM 1.3 showed that the user preferred aggregated estimation equations to the detailed ones using elaborate statistical packages for determining the necessary coefficients. It would be interesting, therefore, to follow the experience of MSAR in this respect.

Chapter 5

THE TUSS MODEL

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1. INTRODUCTION

TUSS stands for "Total University Simulation System". It is essentially a resource prediction model designed for use by the University of Utrecht in the Netherlands. Its first version TUSS-1 was first implemented in 1970. TUSS-2 and TUSS-3 are currently being used. TUSS-3 is the more disaggregated version (at the activity level) and has been implemented in 3 of the 17 faculteiten (equivalent to a division or college in the U.S.A.). TUSS-2 is the more widely implemented (all of the 17 faculteiten) and will be the subject of this chapter. In it will be discussed the basic logic of the model, followed by a discussion of its output.

The logic is described in block diagrams. Because they are largely self-explanatory they will not be discussed in any great detail. Features that are unique will be stressed along with features that need emphasis or clarification. All inputs and outputs will be identified but they will not always follow the ordering of the actual processing or execution of the computer program. Rather, the flows will correspond to what is best from the viewpoint of explanation and comprehension. Further illustrations to the computations can be found in a sample problem solved in the appendix. Additional illustrations can be found in the description of the USG game, which is structured on TUSS and is discussed in great detail in Chapter 13.

2. OVERVIEW OF TUSS

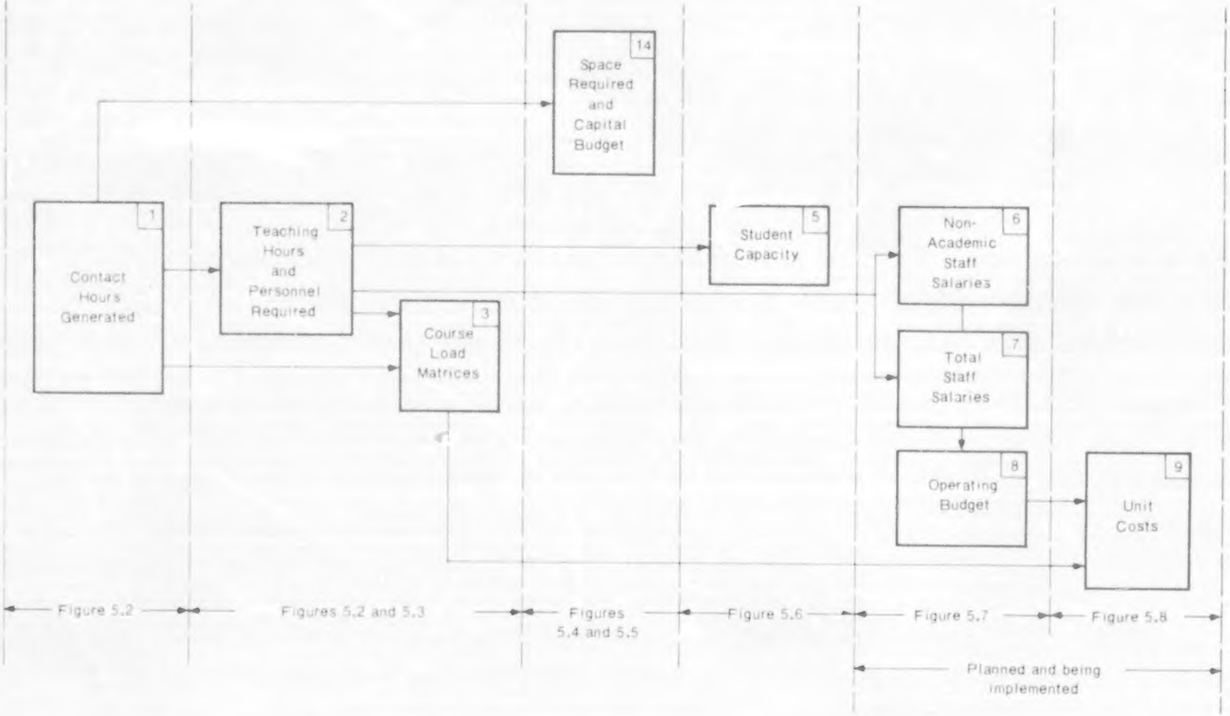
An overview of the model is shown in Figure 5.1. In it the main sets of computations are identified along with a reference to the figure in which the details are shown. The computations of non-academic staff and beyond (boxes 6-9) are identified even though they are not fully implemented.

3. TEACHING RESOURCES REQUIRED

The teaching resources computations are shown in Figure 5.2. These start with the construction of a model of the organizational unit (an academic college, department, or subdepartment). This model is largely definitional, based on structural definitions (box 10) that identify the organizational structure for which resource needs are to be simulated. Examples of the type of structural definitions are shown in Table 5.1.

Figure 5.1

OVERVIEW OF BASIC LOGIC OF TUSS



1 Contact Hours Generated
2 Teaching Hours and Personnel Required
3 Course Load Matrices
14 Space Required and Capital Budget
5 Student Capacity
6 Non-Academic Staff Salaries
7 Total Staff Salaries
8 Operating Budget
9 Unit Costs
Figure 5.2
Figures 5.2 and 5.3
Figures 5.4 and 5.5
Figure 5.6
Figure 5.7
Figure 5.8
Planned and being implemented

Table 5.1

EXAMPLES OF STRUCTURAL DEFINITIONS

- Titles of academic departments or subdepartments (called faculteiten at the Univ. of Utrecht)
- Titles of non-academic departments
- Titles of fields of study or disciplines
- Titles of personnel categories
- Titles of space categories
- Titles of urban areas where buildings are located

These structural definitions are not all used at one time or early in the TUSS computations but are used frequently in many sets of calculations. For convenience, they are loaded early for later use.

The most important input (and a policy variable identified by its symbol) is the hours that each student (in each field of study) devotes in each of his curriculum years to his studies (box 11). This effort is distributed by a given ratio (box 12) into scheduled hours (box 13) and unscheduled hours (box 23). The scheduled hours are lectures (where class size is not significant); small groups (or s.g.) or a seminar or recitation, where class size of a lecture is significant; and finally a laboratory or lab, where class size and equipment are significant. These scheduled hours consume significant resources in space and personnel and their resource implications are calculated separately from the unscheduled hours spent by students in individual work like writing, reading, or internship. Exams are also considered as unscheduled hours because the main consequence of exam time consists of preparation hours for the examination, which is unscheduled time for the student (only the exam itself is sometimes scheduled and this is only 1-3 hours).

The calculation of teaching resources for scheduled hours is calculated for each of the categories of small group and laboratories (boxes 13, 15, 16, 19, 20, 21, and 22). The category of lectures is calculated in the same way except that the calculation of number of groups is omitted here and obtained from input (box 18b).

The non-scheduled hours spent by each student (box 23) is distributed into time spent in exams and individual work (box 25) by using a distribution factor (box 24). These are converted by a ratio of staff effort to student effort (box 26) into teaching effort/year (box 27). This effort is per student since we started with hours per student per year (box 11). This is multiplied by the number of students in the field of study (box 28) to give the total teaching effort, required for non-scheduled work of a student (box 29). This effort, when added to the effort for lecture, lab, and small groups (box 22), gives the total teaching effort required by the instructional staff (box 30). Instructional staff in TUSS is defined as teaching staff (professors, assistant professors, and medewerkers) and student assistants.

The number of students is determined for each field of study in each curriculum year. This can be done exogenously and is so identified in Figure 5.2. However, TUSS is interfaced with four student flow models providing the user with three different approaches (including a Markovian approach) to determining student enrollment allowing for interdepartmental and inter-curriculum-year flow.

Further computations are shown in Figure 5.3. In it the resources needed for student assistants (box 36) and teaching staff (box 41) are calculated in a manner similar to all the other models discussed earlier. In connection with the hours available and the total effort for each instructional staff member (box 36) the load of FTE staff is computed (boxes 37 and 39). These are very important planning variables in the Netherlands since the Minister of Education has stated that this load has to be 1,000 hours per academic year per staff member instead of 700 hours per year used before.

One unique set of calculations in TUSS is the generation of Course Load Matrices (CLM) as output. There are three of these:

CLM for Student Assistants	(box 42)
CLM for Instructional Staff	(box 40)
CLM for Student Hours	(box 43)

In the first two cases, the hours required (of Student Assistants and Instructional Staff respectively) are shown for each field of study. In the third case, the student hours generated by each department are identified for each field of study.

In TUSS, the CLMs are outputs (formats are discussed later) which is distinct from all the other models discussed earlier where the ICLM is an input. In TUSS, it is an output used for analytical purposes, is peripheral to resource prediction but used for the calculation of the student capacity. It does, however, have analytical content, a point often missed by users of the other models where it is treated as an input for the model and no more.

4. SPACE REQUIREMENTS

Space calculations are shown in Figure 5.4. The calculations shown (boxes 46-61) are very similar in principle to those done in RRPM and CAMPUS except that TUSS calculates explicitly the space for the library which is a direct function of all the people (box 58) who use the library. This includes teaching staff (box 52), non-

Figure 5.2

CALCULATION OF TEACHING EFFORT REQUIRED PER YEAR

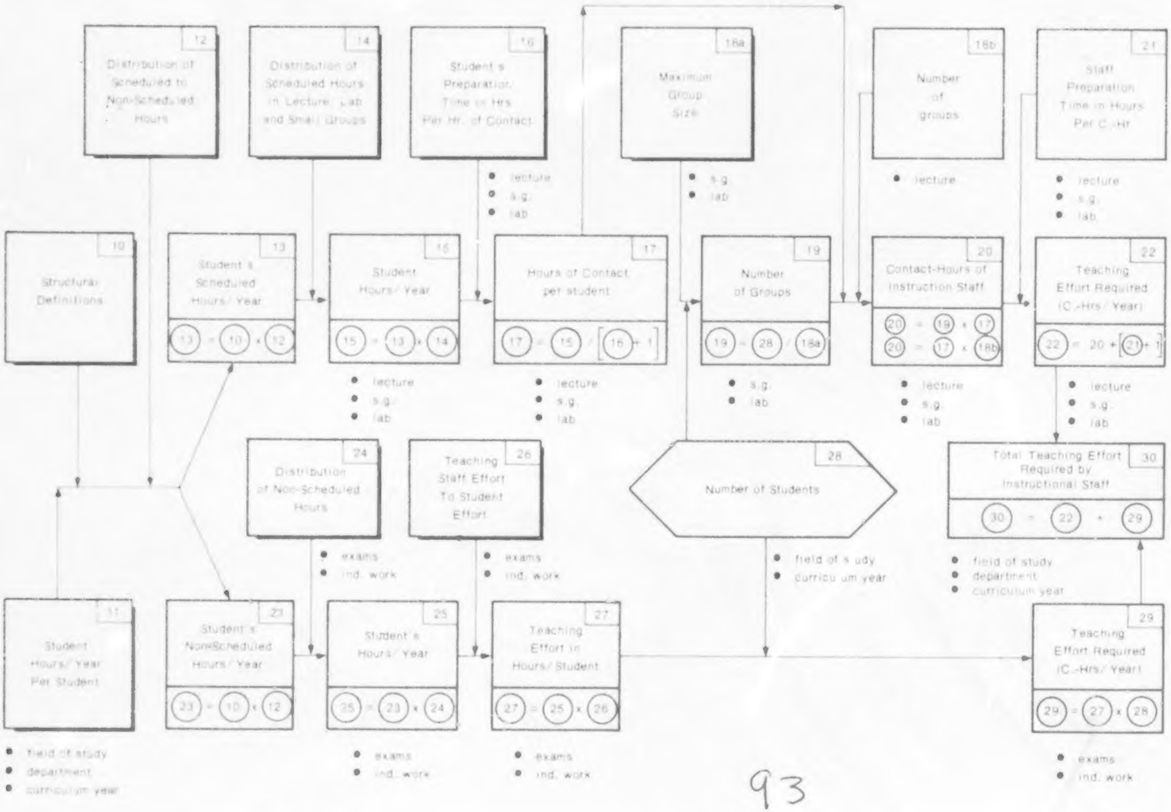
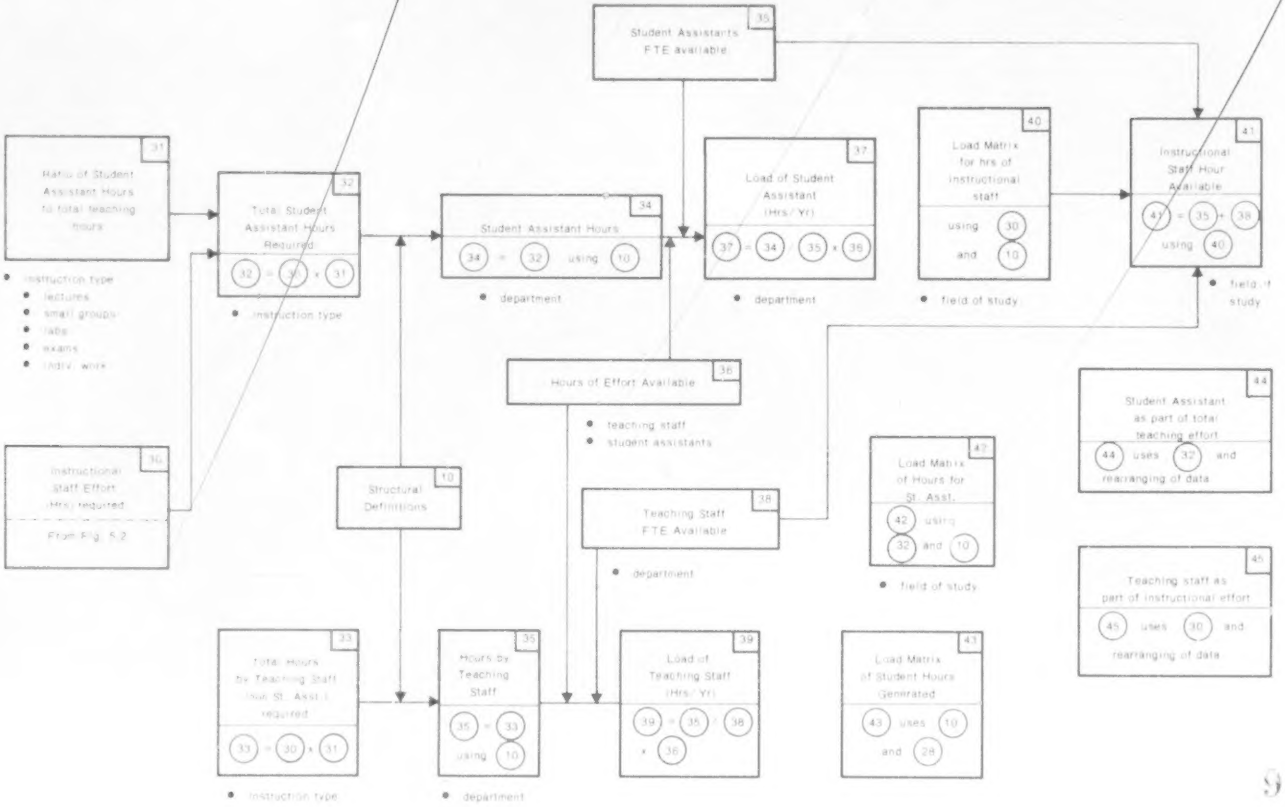
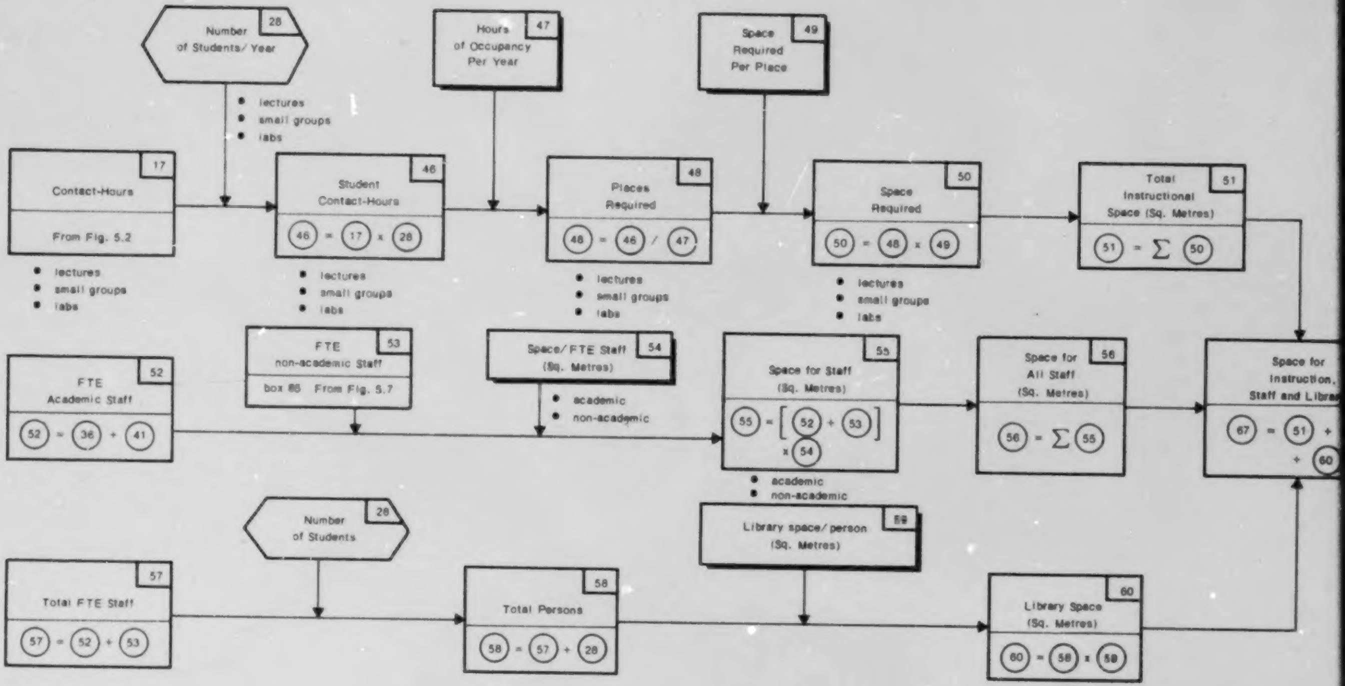

12
Distribution of Scheduled to Non-Scheduled Hours
14
Distribution of Scheduled Hours in Lecture, Lab and Small Groups
16
Student's Preparation Time in Hrs Per Hr. of Contact
• lecture
• s.g.
• lab
18a
Maximum Group Size
• s.g.
• lab
18b
Number of groups
• lecture
21
Staff Preparation Time in Hours Per C.-Hr
• lecture
• s.g.
• lab
10
Structural Definitions
13
Student's Scheduled Hours/Year
(13) = (10) x (12)
15
Student Hours/Year
(15) = (13) x (14)
• lecture
• s.g.
• lab
17
Hours of Contact per student
(17) = (15) / [(16) + 1]
• lecture
• s.g.
• lab
19
Number of Groups
(19) = (28) / (18a)
• s.g.
• lab
20
Contact-Hours of Instruction Staff
(20) = (19) x (17)
(20) = (17) x (18b)
• lecture
• s.g.
• lab
22
Teaching Effort Required (C.-Hrs/Year)
(22) = 20 + [(21) + 1]
• lecture
• s.g.
• lab
24
Distribution of Non-Scheduled Hours
• exams
• ind. work
26
Teaching Staff Effort To Student Effort
• exams
• ind. work
28
Number of Students
• field of study
• curriculum year
30
Total Teaching Effort Required by Instructional Staff
(30) = (22) + (29)
• field of study
• department
• curriculum year
11
Student Hours/Year Per Student
• field of study
• department
• curriculum year
23
Student's Non-Scheduled Hours/Year
(23) = (10) x (12)
25
Student's Hours/Year
(25) = (23) x (24)
• exams
• ind. work
27
Teaching Effort in Hours/Student
(27) = (25) x (26)
• exams
• ind. work
29
Teaching Effort Required (C.-Hrs/Year)
(29) = (27) x (28)
• exams
• ind. work

Figure 5.3

CALCULATIONS FOR LOADING AND LOAD MATRICES

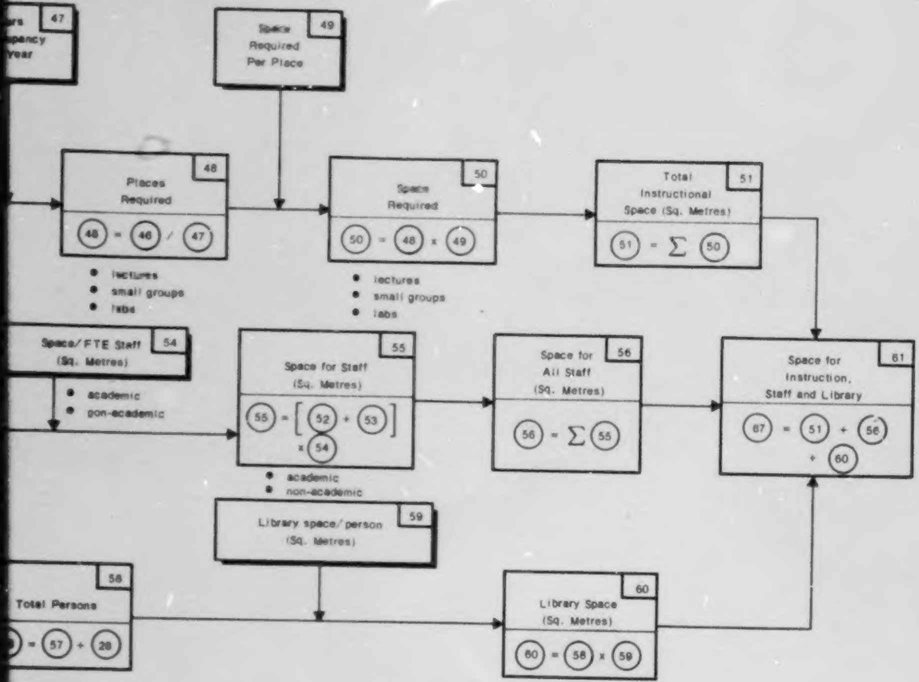

35
Student Assistants
FTE available
31
Ratio of Student
Assistant Hours
to total teaching
hours
• instruction type
• lectures
• small groups
• labs
• exams
• indiv. work
32
Total Student
Assistant Hours
Required
(32) = (30) x (31)
• instruction type
34
Student Assistant Hours
(34) = (32) using (10)
• department
37
Load of Student
Assistant
(Hrs/Yr)
(37) = (34) / (35) x (36)
• department
40
Load Matrix
for hrs of
instructional
staff
using (30)
and (10)
• field of study
41
Instructional
Staff Hour
Available
(41) = (35) + (38)
using (40)
• field of study
36
Hours of Effort Available
• teaching staff
• student assistants
44
Student Assistant
as part of total
teaching effort
(44) uses (32) and
rearranging of data
30
Instructional
Staff Effort
(Hrs) required
From Fig. 5.2
10
Structural
Definitions
38
Teaching Staff
FTE Available
• department
42
Load Matrix
of Hours for
St. Asst.
(42) using
(32) and (10)
• field of study
45
Teaching staff as
part of instructional effort
(45) uses (30) and
rearranging of data
33
Total Hours
by Teaching Staff
(not St. Asst.)
required
(33) = (30) x (31)
• instruction type
35
Hours by
Teaching
Staff
(35) = (33)
using (10)
• department
39
Load of
Teaching Staff
(Hrs/Yr)
(39) = (35) / (38)
x (36)
43
Load Matrix
of Student Hours
Generated
(43) uses (10)
and (28)

CALCULATION OF SPACE NEEDS



Number of Students/ Year
28
• lectures
• small groups
• labs
Hours of Occupancy Per Year
47
Space Required Per Place
49
Contact-Hours
17
From Fig. 5.2
• lectures
• small groups
• labs
Student Contact-Hours
46
46 = 17 x 28
• lectures
• small groups
• labs
Places Required
48
48 = 46 / 47
• lectures
• small groups
• labs
Space Required
50
50 = 48 x 49
• lectures
• small groups
• labs
Total Instructional Space (Sq. Metres)
51
51 = ∑ 50
FTE Academic Staff
52
52 = 36 + 41
FTE non-academic Staff
53
box 86 From Fig. 5.7
Space/FTE Staff (Sq. Metres)
54
• academic
• non-academic
Space for Staff (Sq. Metres)
55
55 = [52 + 53] x 54
• academic
• non-academic
Space for All Staff (Sq. Metres)
56
56 = ∑ 55
Space for Instruction, Staff and Libra
67 = 51 +
+ 60
Number of Students
28
Library space/ person (Sq. Metres)
59
Total FTE Staff
57
57 = 52 + 53
Total Persons
58
58 = 57 + 28
Library Space (Sq. Metres)
60
60 = 58 x 59

CALCULATION OF SPACE NEEDS


47
rs
pancy
year
Space Required Per Place
49
Places Required
48
48 = 46 / 47
lectures
small groups
labs
Space Required
50
50 = 48 x 49
lectures
small groups
labs
Total Instructional Space (Sq. Metres)
51
51 = Σ 50
Space/FTE Staff (Sq. Metres)
54
academic
non-academic
Space for Staff (Sq. Metres)
55
55 = [52 + 53] x 54
academic
non-academic
Space for All Staff (Sq. Metres)
56
56 = Σ 55
Space for Instruction, Staff and Library
61
67 = 51 + 56 + 60
Library space/person (Sq. Metres)
59
Total Persons
58
= 57 + 28
Library Space (Sq. Metres)
60
60 = 58 x 59

that all type of personnel make the same degree of use of the library.

Additional space calculations are shown in Figure 5.5. In it "other" space (box 63) is calculated as a function (box 62) of the space needed for academic and non-academic personnel as well as library. This "other" space includes "overhead" space such as corridors, restrooms, storage rooms, entrances, etc.

The total space requirements are then totalled (box 65) and done according to urban areas. This is unique to TUSS because of the nature of the location of the University of Utrecht. It will eventually be housed in a large modern campus now being built on the outskirts of the town of Utrecht. Meanwhile, many of the classes are held in buildings in downtown Utrecht as are some of the offices, including the Office of Planning that has developed and maintains the TUSS model. Thus space calculations must be done for each urban area for each planning period according to specifications stated as a set of policy variables (box 64). These specifications identify the department and the number of personnel in each department that should be housed in each urban area. This would ideally reduce the walking distance and travelling time for personnel getting to work.

For each urban construction further building specifications are required (box 67). These include the following:

- Departments or subdepartments that are going to use the building
- Academic year in which construction of the building starts
- Time required for construction in academic year

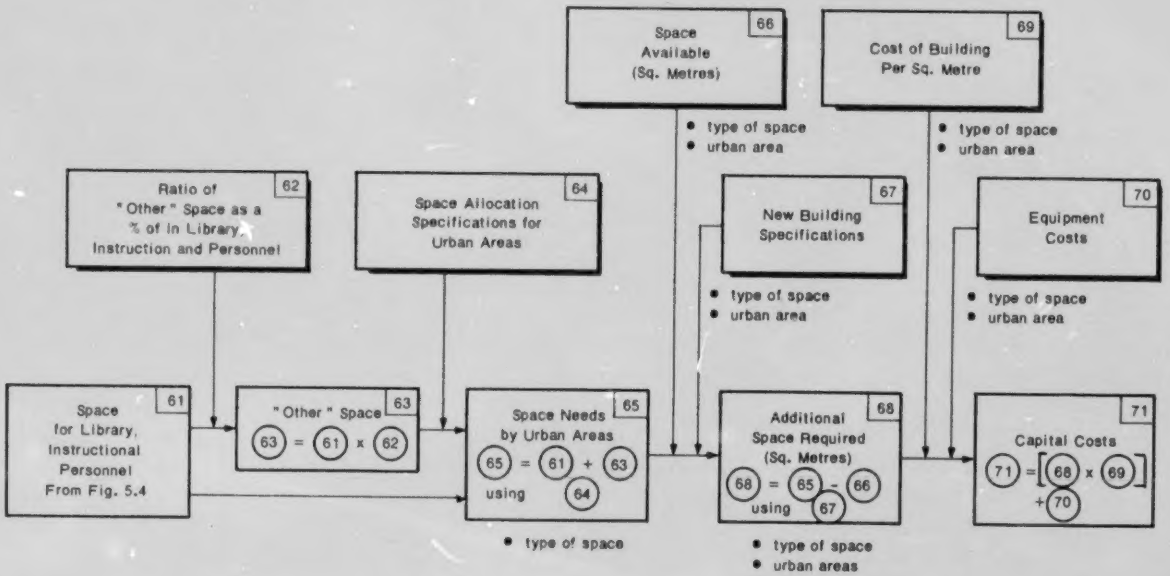
The space required for buildings (box 65) is calculated for each type of space. TUSS allows for the types shown in Table 5.2.

Table 5.2

SPACE TYPES

- Lecture rooms
- Small group rooms
- Laboratories
- Rooms for specific needs (such as rooms for water, gas, air conditioning, etc.)
- Rooms for non-specific needs (such as office)
- Library rooms
- Other rooms (such as corridors, staircases, vestibules, toilets, etc.)

CALCULATION OF SPACE NEEDS AND CAPITAL BUDGET


Space Available (Sq. Metres) 66
• type of space
• urban area
Cost of Building Per Sq. Metre 69
• type of space
• urban area
Ratio of "Other" Space as a % of In Library, Instruction and Personnel 62
Space Allocation Specifications for Urban Areas 64
New Building Specifications 67
• type of space
• urban area
Equipment Costs 70
• type of space
• urban area
Space for Library, Instructional Personnel From Fig. 5.4 61
"Other" Space 63
63 = 61 x 62
Space Needs by Urban Areas 65
65 = 61 + 63
using 64
• type of space
Additional Space Required (Sq. Metres) 68
68 = 65 - 66
using 67
• type of space
• urban areas
Capital Costs 71
71 = [68 x 69] + 70

the space needs (requirements less inventory) for each type of space and each urban area (box 68) is multiplied by its corresponding construction cost coefficient (box 69). In addition, there are "first" equipment costs that are required before the building can be used. These are typically a fixed percentage of the new building cost (box 70) but would vary with the type of rooms in it. The equipment cost and the new building cost then constitute the capital budget (box 71) of the last academic year before the finish of the construction.

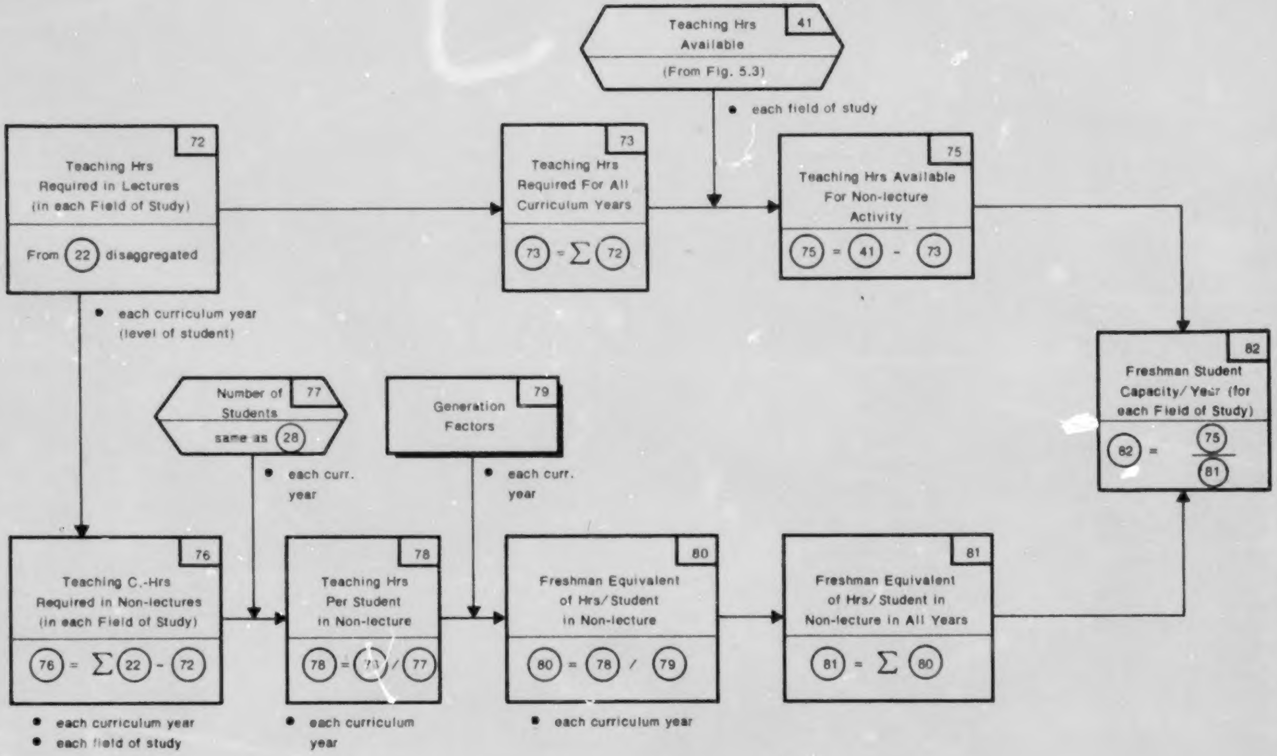
5. STUDENT CAPACITY

Space is sometimes a constraint in determining enrollment ceilings in many disciplines. This is true of the HIS model when determining freshmen enrollment for numerous clausus disciplines. There exists numerous clausus in the Netherlands too, but the constraint there is the available teaching contact hours. This is determined from the expected availability of teaching personnel for the planning period and is determined exogenously (box 41 in Figure 5.6). The teaching hours could be influenced by the contact hours of space available but if this is desirable then this must be done external to the model. The model separates the required teaching hours into two categories: those that are independent of the number of students (boxes 72 and 73) and those dependent on the number of students (box 76), which includes small groups, labs, exams, and individual work.

The hours for lectures for each curriculum year (box 72) is added up for all curriculum years (box 73) and this is subtracted from the total hours available for the year of planning (box 41). The remainder (box 75) is the teaching hours available for all non-lecture academic activity dependent on student number. When this is divided by the hours required for each freshman (box 81) it will give the freshmen capacity for the planning year (box 82). Determining the freshmen hours is now the remaining problem. In any year there are not just freshmen but students in other curriculum years (years 2, 3, 4, and 5). These must be converted to freshmen equivalent, for a number of freshmen is not the same as the number of students in future curriculum years because of dropouts, withdrawals, and failures. The conversion can be done by using a generation factor which is the ratio of students in a non-freshman year to its equivalent freshman year. An illustration may help. Consider having 100 freshmen that become 80 in year 4 and 70 in year 5. The generation factor for year 5 is 0.7 (70 in year 5 divided by 100 as freshmen) and 0.8 in year 4. Thus there is a generation factor for each curriculum year. Now to determine the freshmen equivalent of a number of

Figure 5.6

CALCULATION OF ANNUAL FRESHMAN CAPACITY


Teaching Hrs
Available
41
(From Fig. 5.3)
• each field of study
72
Teaching Hrs
Required in Lectures
(in each Field of Study)
From 22 disaggregated
• each curriculum year
(level of student)
73
Teaching Hrs
Required For All
Curriculum Years
73 = Σ 72
75
Teaching Hrs Available
For Non-lecture
Activity
75 = 41 - 73
82
Freshman Student
Capacity/ Year (for
each Field of Study)
82 = 75 / 81
Number of
Students
77
same as 28
• each curr.
year
Generation
Factors
79
• each curr.
year
76
Teaching C.-Hrs
Required in Non-lectures
(in each Field of Study)
76 = Σ 22 - 72
• each curriculum year
• each field of study
78
Teaching Hrs
Per Student
in Non-lecture
78 = 76 / 77
• each curriculum
year
80
Freshman Equivalent
of Hrs/ Student
in Non-lecture
80 = 78 / 79
• each curriculum year
81
Freshman Equivalent
of Hrs/ Student in
Non-lecture in All Years
81 = Σ 80

curriculum year by its corresponding generation factor. Thus for example the freshmen equivalent of 70 in year 5 of the previous example is 100 (70/0.7, the number of students 70 divided by its generation factor 0.7). This is the number of freshmen we had in our example to start with.

We can now use the generation factors to calculate the freshmen equivalent. We start with the hours in non-lecture activities (box 76) and divide it by the number of students in each curriculum year determined from the Student Flow Model (box 77). This gives an hour per student for non-lecture activity (box 78). This divided by the corresponding generation factors for each curriculum year (box 79) gives the freshmen equivalent of hours per student in each curriculum year (box 80) required for non-lecture activity. These when added give an hour requirement for all curriculum years (box 81) for non-lecture activity. The hours available for non-lecture activity (box 75) is now divided by the hours required for each freshman equivalent student (box 81) giving the freshmen that can be sustained (box 82) given the hour constraints (boxes 74 and 75). This then constitutes the freshmen capacity for the given planning period and for the field of study for which the calculations were done.

6. OPERATION BUDGET

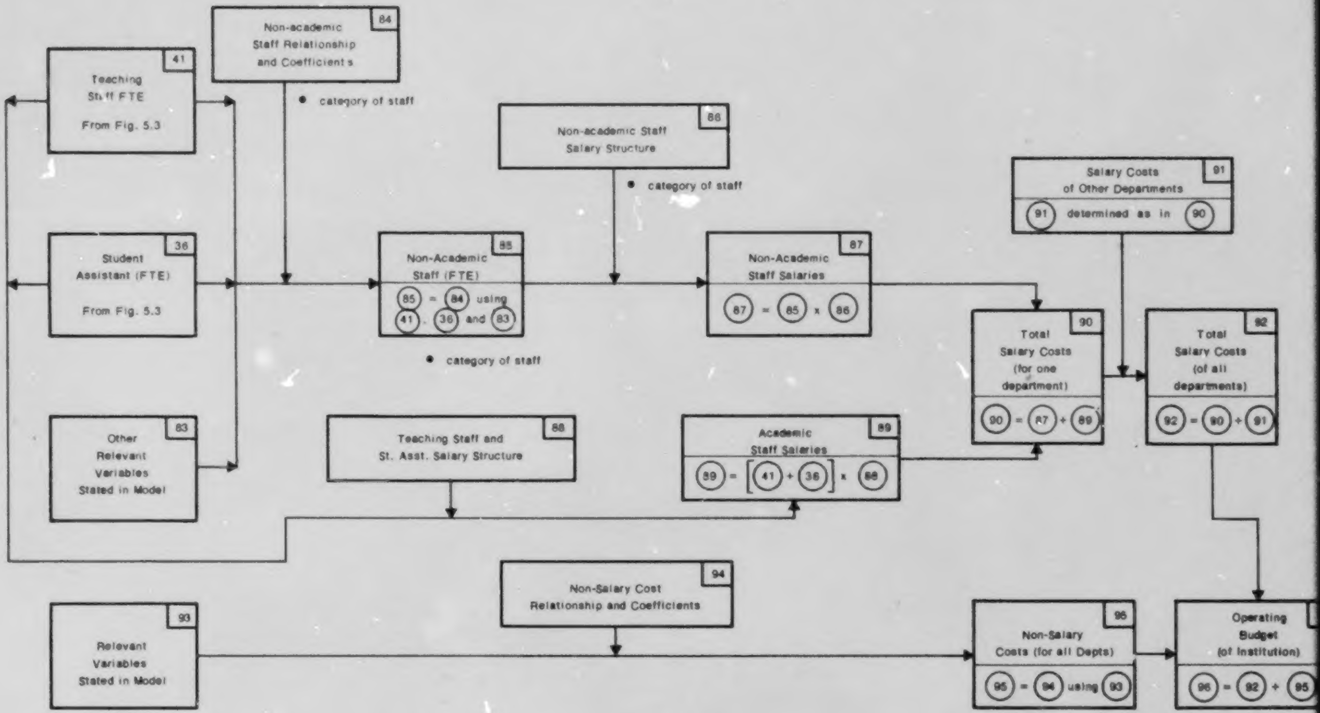
The calculations leading up to an operating budget is not part of the original TUSS model. It is an extension that is currently being implemented and validated. It is conceptionally much along the lines of CAMPUS and RRPM, both in its extension into the non-academic sector as well as the extension into cost and costing. These extensions are shown in Figures 5.7 and 5.8. It starts with the FTE of teaching, staff, and student assistants determined in the resource calculations (boxes 41 and 36 in Figure 5.3) which are the basis of the non-academic staff calculation. This is done by using an estimation relationship (box 84) of the following type:

$$Y = a + b_1X_1 + b_2X_2 + \ldots b_nX_n$$

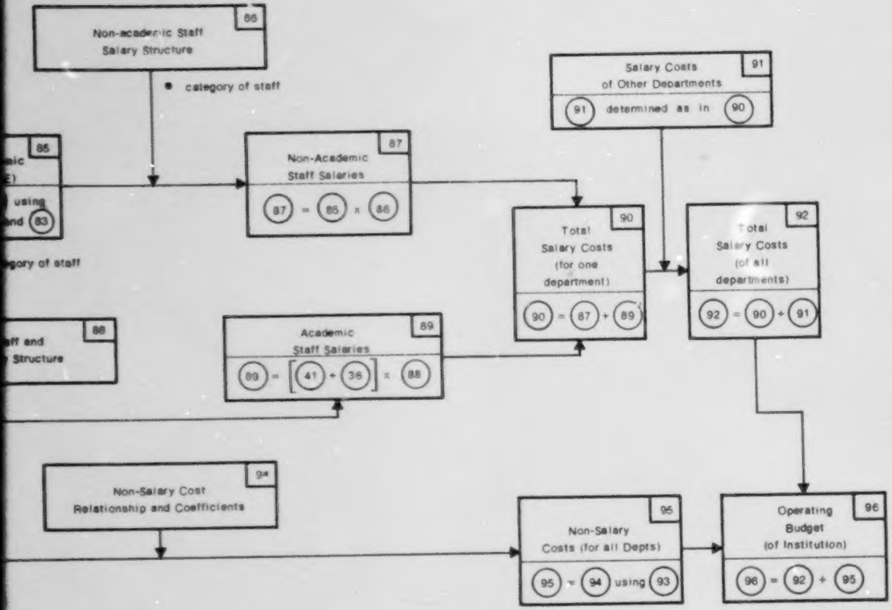
Where Y = the variable to be estimated
a = fixed constant
X_1 = variable 1
.
.
.
X_n = variable n
b_1 = variable coefficient for variable X_1
.
.
.
b_n = variable coefficient for variable X_n

Figure 5.7

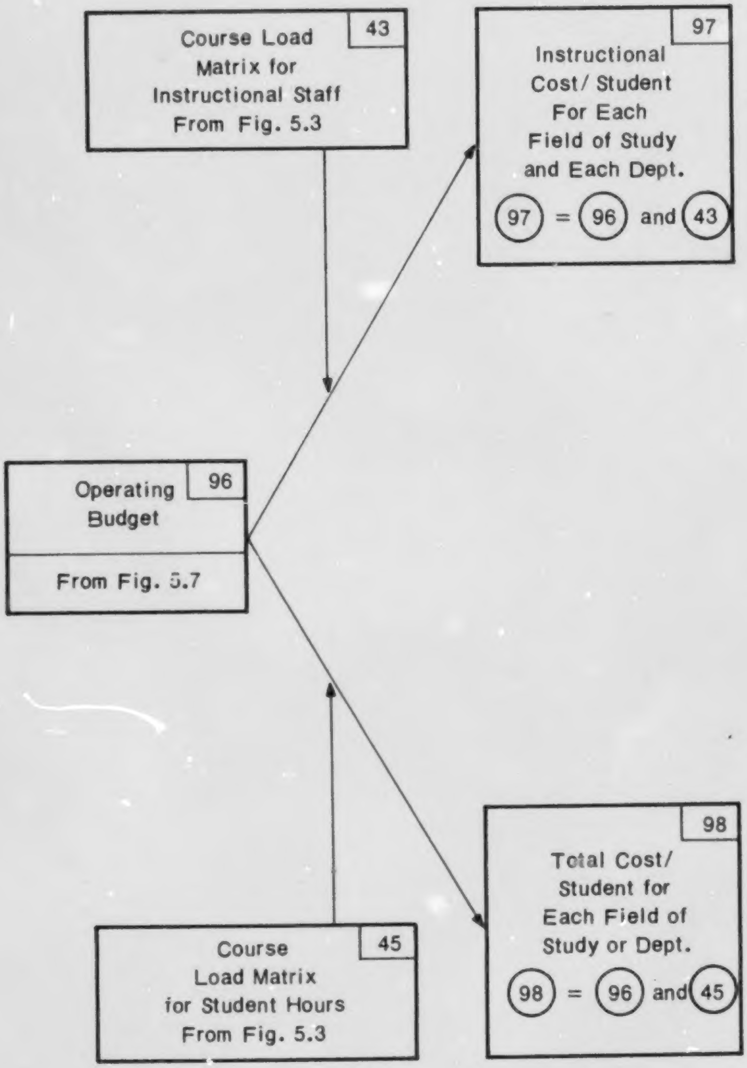
CALCULATION OF NON-ACADEMIC STAFF AND OPERATION BUDGET OF INSTITUTION
(PLANNED OR PARTIALLY IMPLEMENTED)


84
Non-academic Staff Relationship and Coefficients
41
Teaching Staff FTE
From Fig. 5.3
• category of staff
86
Non-academic Staff Salary Structure
• category of staff
91
Salary Costs of Other Departments
91 determined as in 90
36
Student Assistant (FTE)
From Fig. 5.3
85
Non-Academic Staff (FTE)
85 = 84 using 41, 36 and 83
87
Non-Academic Staff Salaries
87 = 85 x 86
90
Total Salary Costs (for one department)
90 = 87 + 89
92
Total Salary Costs (of all departments)
92 = 90 + 91
• category of staff
83
Other Relevant Variables Stated in Model
88
Teaching Staff and St. Asst. Salary Structure
89
Academic Staff Salaries
89 = [41 + 36] x 88
94
Non-Salary Cost Relationship and Coefficients
93
Relevant Variables Stated in Model
95
Non-Salary Costs (for all Depts)
95 = 94 using 93
Operating Budget (of Institution)
96 = 92 + 95

-ACADEMIC STAFF AND OPERATION BUDGET OF INSTITUTION (PLANNED OR PARTIALLY IMPLEMENTED)


86
Non-academic Staff Salary Structure
• category of staff
85
mic
E)
) using
and 83
gory of staff
87
Non-Academic Staff Salaries
87 = 85 x 86
91
Salary Costs of Other Departments
91 determined as in 90
90
Total Salary Costs (for one department)
90 = 87 + 89
92
Total Salary Costs (of all departments)
92 = 90 + 91
88
ff and
Structure
89
Academic Staff Salaries
89 = [41 + 36] x 88
94
Non-Salary Cost Relationship and Coefficients
95
Non-Salary Costs (for all Depts)
95 = 94 using 93
96
Operating Budget (of Institution)
96 = 92 + 95

CALCULATING UNIT COSTS
(PLANNED OR PARTIALLY IMPLEMENTED)


43
Course Load Matrix for Instructional Staff From Fig. 5.3
97
Instructional Cost/ Student For Each Field of Study and Each Dept.
97 = 96 and 43
96
Operating Budget
From Fig. 5.7
98
Total Cost/ Student for Each Field of Study or Dept.
98 = 96 and 45
45
Course Load Matrix for Student Hours From Fig. 5.3

In this case, Y is the variable of non-academic staff that is to be estimated; X_1 is the FTE of teaching staff; and X_2 is the FTE of student assistants. There may be other variables (box 83) such as the number of students or the number of administrative units. Their relationship is defined in the estimation equation and is a policy variable (box 84) along with the coefficients: $a_1, b_1, b_2 \ldots b_n$ (box 84). There is one equation for each type of non-academic staff such as secretary, supervisor, etc. Currently in TUSS there are four such categories. This set of four equations are calculated for each administrative unit (academic and non-academic departments).

The FTE non-academic staff (box 85) is then multiplied by the non-academic staff salary schedule for each staff category (box 86) to give the salary costs for non-academic staff (box 87). Similarly, academic staff salaries (box 89) is calculated by multiplying the FTE academic staff (boxes 36 and 41) with its corresponding staff schedule (box 88). The summation of salaries for academic and non-academic staff give the total salaries. These calculations are done for each department (academic and non-academic) (box 90) and when totalled for all departments (boxes 90 and 91) giving the total salary cost (box 92). This constitutes roughly 80 per cent of the institutional operational budget. The remaining cost component is the non-salary costs (box 95) and is calculated by a non-salary relationship and coefficients (box 94) which is similar in principle to the non-academic staff relationship discussed earlier. The relevant variables (box 93) are stated in the relationship. They may be endogenous like the number of students or they may be exogenous such as the inflation factor, cost of living index, number of degrees offered, age of teaching faculty, etc.

The final set of computations start with the salary cost being summed with non-salary costs yielding the operating budget (box 96). This when related with the course load matrices of instructional staff (box 43 from Figure 5.3) and student hours (box 44 from Figure 5.3) give the instructional cost per student (box 97) and total cost per student (box 98) respectively. These unit costs can be calculated for each field of study or each academic department.

7. OUTPUT

An example of an actual output (and its input) of the TUSS model is shown in the appendix. It identifies the intermediate and final computation of hours needed of teaching staff and student assistants. These and other outputs are identified in the preceding figures on logic. Almost all intermediate computations appear on some output report. The most important of these not identified in the appendix are shown in Table 5.3.

PART OF THE OUTPUT OF TUSS

FTE required	Figure 5.3
. Teaching staff	
. Student Assistants	
Course Load Matrices	
. Student Assistants	
. Instructional staff	
. Student Hours	
Space Required	Figure 5.4
. Teaching	
. Personnel	
. Library	
. Other	Figure 5.5
. Total	
. By urban areas	
Equipment Cost	
Capital Budget	
Student Capacity	Figure 5.6
Salary Costs	Figure 5.7
. Academic	
. Non-Academic	
. Total	
Other Expenses	
Operating Budget	
Unit Cost / Student	Figure 5.8
. Instructional	
. Total	

The output unique to TUSS that could well be relevant to users of other allocation models are the load matrices. A sketch identifying the contents by type for each matrix is shown in Tables 5.4 - 5.6. These tables correspond to boxes 38, 43, and 45 respectively.

FORMAT OF HOURS FOR STUDENT ASSISTANTS

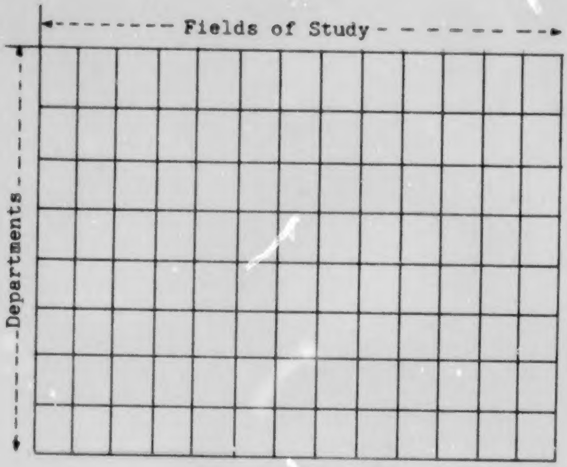
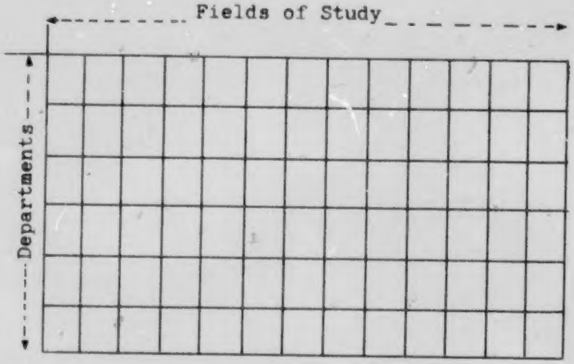
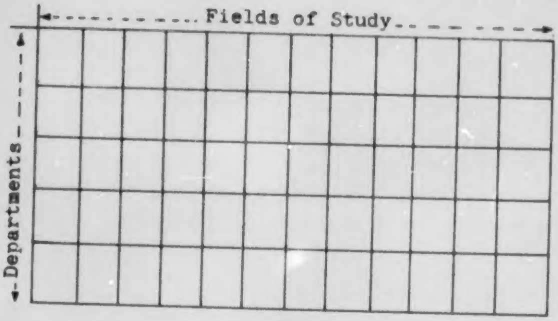

Fields of Study
Departments

Table 5.5

HOURS FOR INSTRUCTIONAL STAFF
(Teaching Staff and Student Assistants)


Fields of Study
Departments

STUDENT HOURS GENERATED



The inputs are also of considerable analytical value. They are used for comparisons between departments and for control of departments, colleges, and institutions. The most important of these inputs are shown in Table 5.7.

Table 5.7

INPUT FOR TUSS

---

1. Curriculum description for each department and field of study
    - distribution of student's hours in
        - scheduled work
        - unscheduled
    - distribution of student's scheduled hours
        - lecture
        - lab
        - small group
    - distribution of student's unscheduled hours in
        - exams
        - individual work
    - preparation time in hours per contact-hour in
        - lecture
        - lab
        - small group

      of
        - student
        - teaching staff
    - groups
        - number
        - maximum size
    - ratio of staff to student effort
        - exams
        - individual work
2. Inventory available
    - teaching staff
    - student assistants
    - space

- Ratios. Student teaching hours to total teaching hours
- Space allocation specification
- Cost of building by type and location
- Equipment cost
- Non-academic staff relationships and coefficients
- Non-salary cost relationships and coefficients
- Salary structure

Other output are responses to "what-if" questions. Both the inputs and the format of the output are very well designed for such simulations of the planning process. This sub-system is very well documented for the convenience of the user allowing him to experiment with policy variables. This interaction can be either on line from a terminal or in batch with overnight responses.

Appendix

PROBLEM AND SOLUTION TO TUSS

This appendix shows a TUSS solution to a problem in resource allocation. It is, however, confined to the calculation teaching resources required for a given set of planning variables.

This appendix has two objectives. One is to identify the intermediate and final results of resource calculations and thereby illustrate the logic of the TUSS model through a numerical solution. Two, is to display the format of both the input and output of the TUSS model.

The planning variables for this problem are as follows:

Percentage time spent by student in scheduled activity = 49.5
Percentage time spent by student in non-scheduled activity = 50.5
    Ratio of scheduled hours in lecture = 1/3
    Ratio of scheduled hours in lab = 2/3
    % of non-scheduled hours in exams = 80%
    % of non-scheduled hours in individual work = 20%
Total hours spent by student/year = 1500
    No. of lecture groups = 100
    No. of laboratories = 15
No. of students in curriculum year = 90
Preparation time of student in hours per contact-hour for
- lecture = 1
- small group = 1
- lab = 1

Preparation time of staff in hour per contact-hour
- lecture = 2
- small group = 1
- lab = 1

Ratio of staff to student effort in
- exams = 2
- individual work = 2

Number of faculty/subfaculty available = 4

Identification information for data

Field of study code = 5
Curriculum year code = 2

curriculum year	2
percentage of participation	100

(a) student-hours per year	1 500.0	
	scheduled student-hours	non-scheduled student hours
(b)	742.0	758.0

	lectures	small groups	laboratory	exams	individual work	total
(c)	245.0		497.0	606.0	152.0	
(d) preparation-time student in hours per contact-hour	2.00		0.50			
(e) contact-hours per student $\left(\frac{c}{d+1}\right)$	81.6		331.3			
(f) maximum group size			15.0			
(g) number of groups $\frac{k}{f}$	1.00		6.00			
(h) contact-hours instructional staff (e x g)	81.6		1 987.8			
(i) preparation time instructional staff in hours per contact-hours	3.00		2.00			
(j) ratio staff effort to student effort (x 100) as % of c				2.0	10.0	
(k) number of students				90.0	90.0	
(l) teaching hours needed $(h \times (i+1) ; \frac{j \times c}{100}) \times k$	326.4		5 963.4	1 090.8	1 368.0	8 748.6
(m) percentage student-assistents as percentage of l	0.0		10.0	0.0	0.0	
(n) hours needed student-assistants as part of the teaching hours needed $\frac{l \times m}{100}$	0.0		596.3	0.0	0.0	596.3

Mutation number ☐☐☐

1	2	3	4	5	
		1.			Preparation time student
6	7	8	9	10	
		1.			
11	12	13	14	15	
		1.			
16	17	18	19	20	
		2.			Preparation time staff
21	22	23	24	25	
		1.			
26	27	28	29	30	
		1.			
31	32	33	34	35	
		2.			Ratio staff effort to student effort (x 100)
36	37	38	39	40	
		2.			
41	42	43	44	45	
		0.			Percentage student assistants
46	47	48	49	50	
		0.			
51	52	53	54	55	
		0.			
56	57	58	59	60	
		0.			
61	62	63	64	65	
		0.			

mutation number ☐☐☐

	1 2	☐ 4	number faculty/ subfaculty
	3 4	☐ 5	number field of study
	5 6	☐ 2	curriculum year
	7 8 9	☐ ☐ ☐	percentage of participation (if not entered 100 % is assumed)
A	10 11 12 13	☐ 2 4 5	student-hours lectures
A	14 15 16 17	☐ ☐ ☐ ☐	small groups
A	18 19 20 21	☐ 4 9 7	laboratories
B	22 23 24 25	☐ 6 0 6	exams
B	26 27 28 29	☐ 1 5 1	individual work
A	30 31 32 33	☐ ☐ ☐ ☐	contact-hours lectures
A	34 35 36 37	☐ ☐ ☐ ☐	small groups
A	38 39 40 41	☐ ☐ ☐ ☐	laboratories
	42 43 44	1 0 0	number of groups lectures
	45 46	☐ ☐	maximum group size small groups
	47 48	1 5	laboratories
	49 50 51 52	☐ ☐ 9 0	number of students in the curriculum year (100 %)
B	53 54 55 56 57	☐ ☐ ☐ ☐ ☐	instructional staff hours exams
B	58 59 60 61 62	☐ ☐ ☐ ☐ ☐	individual work
	63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	remarks

Note : only one bloc A has to be entered
only one bloc B has to be entered

Chapter 6

COMPARISON OF ALLOCATION MODELS

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1. INTRODUCTION

Having discussed five resource allocation models in higher education (CAMPUS, HIS, MSAR, RRPM and TUSS), it may be helpful to compare them. Such a comparison is done for the logical structure of the model as well as their planning factors, dimensions, and technical data. Finally, the capabilities and limitations of these models are examined.

2. BASIC LOGICAL DIFFERENCES

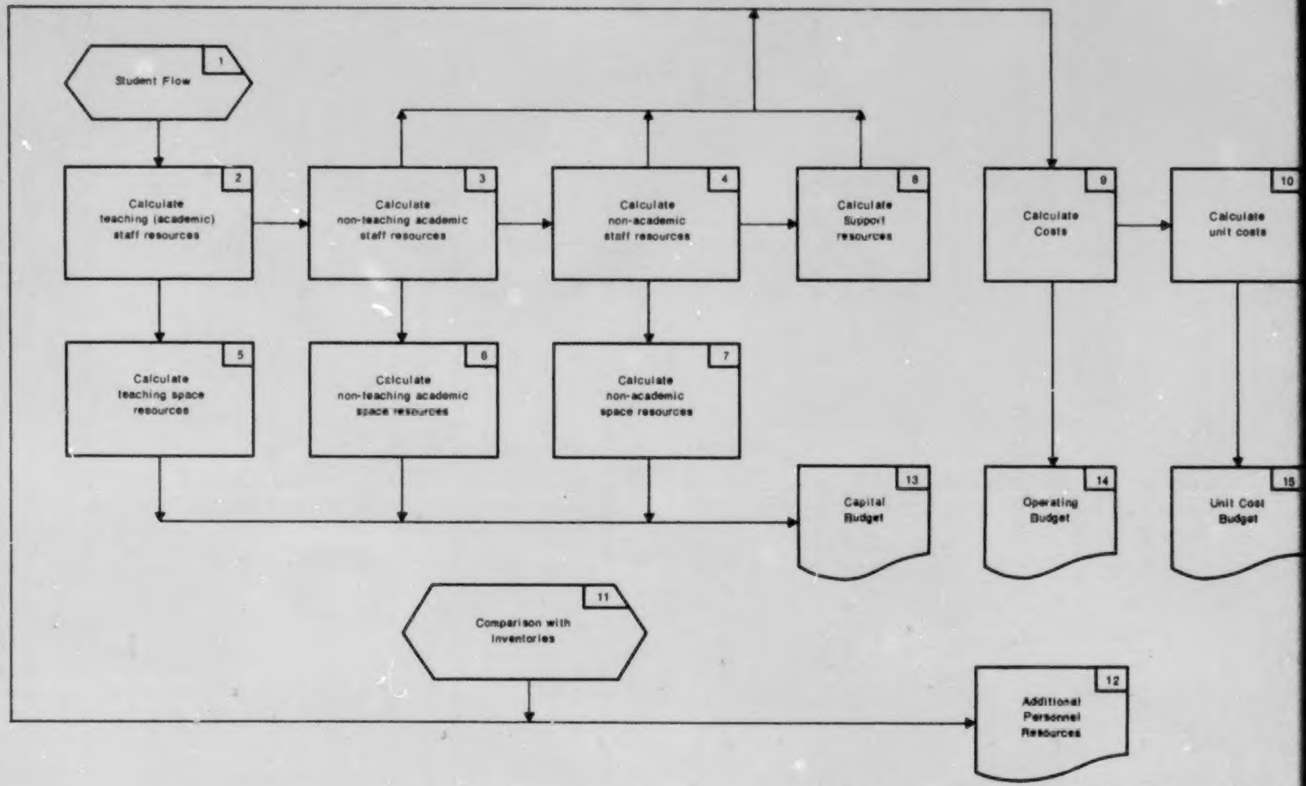
The five models discussed in previous chapters vary greatly in their scope and comprehensiveness of the calculations performed. The differences can perhaps best be examined in a diagram that shows all the main components of a comprehensive model of resource allocation. Such a diagram is Figure 6.1. The main components identified therein are tabulated in Figure 6.2, showing which component calculations are performed by the five different models.

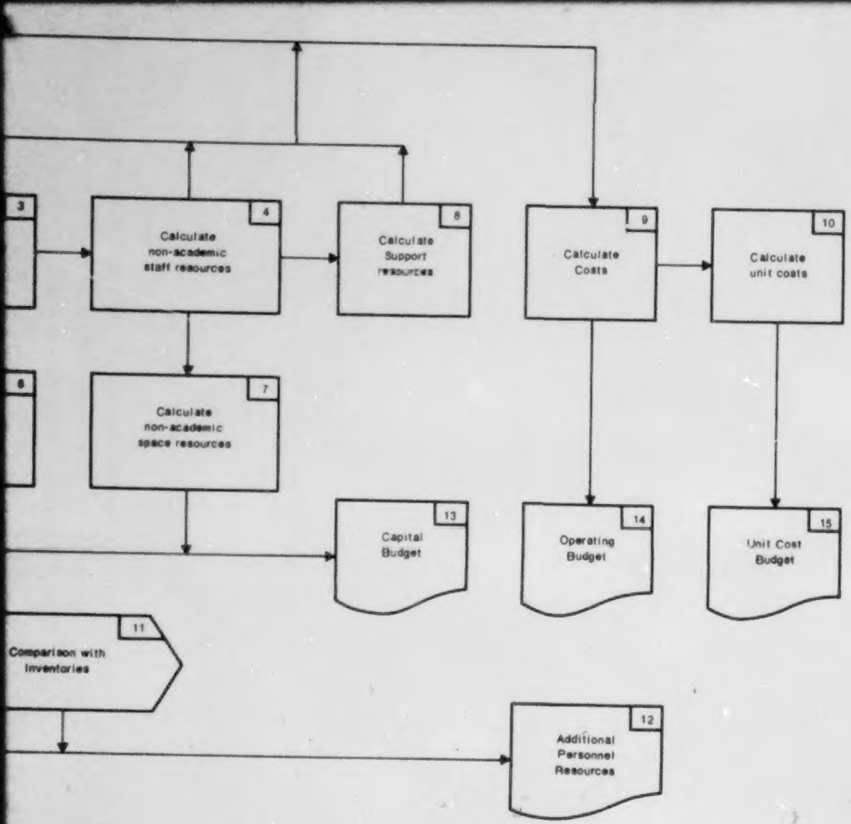
An examination of Figure 6.1 and Figure 6.2 reveals that CAMPUS and RRPM are comprehensive in terms of main computations being performed; RRPM is less comprehensive in output (does not perform boxes 11 and 12). HIS calculates the teaching staff resources (boxes 1-2) as well as the teaching space resources (box 5); MSAR is concerned with all academic staff (boxes 2-3), not the student flow (box 1), some non-academic staff (box 4) and teaching space resources (box 5); while TUSS has four student flow models (box 1), calculates teaching resources in all its versions (boxes 2 and 5) and is currently implementing the non-teaching resource calculation as well as costing (remaining boxes). TUSS is different from all other models in that it does not start with the ICLM but makes the teaching resource needs a function of the time spent by students on different activities like lecture, lab, small groups, exams, and individual work.

The common set of calculations for all models is the calculation of teaching staff resources. Only CAMPUS and RRPM include the non-academic sector. This is partly because it is relatively large in the U.S. and its resources can be reallocated. In the case of the other models, the non-academic sector is either small and unimportant, or it consists largely of civil servants who cannot easily be reallocated.

CAMPUS and RRPM are the only models concerned with costing. This is largely because of the importance of accountability in the U.S.

COMPUTATIONS OF A COMPREHENSIVE ALLOCATION MODEL


1
Student Flow
2
Calculate teaching (academic) staff resources
3
Calculate non-teaching academic staff resources
4
Calculate non-academic staff resources
8
Calculate Support resources
9
Calculate Costs
10
Calculate unit costs
5
Calculate teaching space resources
6
Calculate non-teaching academic space resources
7
Calculate non-academic space resources
13
Capital Budget
14
Operating Budget
15
Unit Cost Budget
11
Comparison with inventories
12
Additional Personnel Resources


3
4
Calculate non-academic staff resources
8
Calculate Support resources
9
Calculate Costs
10
Calculate unit costs
6
7
Calculate non-academic space resources
13
Capital Budget
14
Operating Budget
15
Unit Cost Budget
11
Comparison with Inventories
12
Additional Personnel Resources

Capabilities of Model	Box Referred to in Figure 6.1	CAMPUS	HIS	MSAR	RRPM	TU
ICLM	1	input	input	input	input	out
Student Flow Model						
transitions	1	disaggregated	aggregated	none yet	disaggregated	aggr
Calculation of resources						
academic staff	2					
teaching		Yes	Yes	Yes	Yes	Ye
non-teaching	3	Yes	No	Yes	Yes	Bei
non-academic staff	4	Yes	No	Maintenance only	Yes	imple
other support	8	Yes	No	No	Yes	
space						
teaching academic	5	Yes	Yes	Yes	Yes	Ye
non-teaching academic	6	Yes	No	No	Yes	Ye
non-academic	7	Yes	No	No	Yes	Ye
Calculation of needed resources from inventories	11 12	Yes	Yes	Yes	No	No
Conversion of resources to monetary units (costs)	9 14	Yes	No	No	Yes	No
Unit costing			No	No		Bei
per st. co. hr.	10	Yes			Yes	imple
per degree	15	Yes	No	No	Yes	No

	Box Referred to in Figure 6.1	CAMPUS	HIS	MSAR	RRPM	TUSS
	1	input	input	input	input	output
	1	disaggregated	aggregated	none yet	disaggregated	aggregated
ces						
	2	Yes	Yes	Yes	Yes	Yes
	3	Yes	No	Yes	Yes	Being implemented
	4	Yes	No	Maintenance only	Yes	
	8	Yes	No	No	Yes	
	5	Yes	Yes	Yes	Yes	Yes
mic	6	Yes	No	No	Yes	Yes
	7	Yes	No	No	Yes	Yes
	11					
ries	12	Yes	Yes	Yes	No	No
s to	9					
s)	14	Yes	No	No	Yes	No
			No	No		
	10	Yes			Yes	Being implemented
	15	Yes	No	No	Yes	No

their costs are used for control and as an indicator of performance. The importance of costing is increasing to the point that it is becoming more important than resource allocation, a trend that will be examined in the next chapter. The developers of the other models, HIS, MSAR, and TUSS also show an interest in costing. One reason for their not having yet done costing is the lack of resources for model development. This is especially true in the case of MSAR and TUSS which have been developed entirely on institutional resources unlike HIS that did much of its original development on Foundation grants (like CAMPUS) and is partly supported by federal funds (like NCHEMS). The shortage of development resources is not helped by the lack of contact between the model developers. This is especially true of the developers of the HIS and TUSS model who did not know of each other's development even though they were separated by only a six-hour journey by train. It resulted in some reinventing of the wheel which could have been avoided. It was avoided by the MSAR developers that adopted much of the basic concepts of CAMPUS and RRPM and then concentrated on its adaptation to the local environment and in extending the model beyond the then state of the art.

3. OTHER LOGICAL DIFFERENCES

Other logical differences are tabulated in Figure 6.3. The most important of these differences concern the level of detail. RRPM is the only model (of the five compared) that is at the aggregated level of the discipline or department. This was a deliberate design specification largely to reduce the mass of data required, reduce problems of data instability(1) and reduce the cost of data maintenance(2). The need and desirability of aggregation was justified and is reflected in the trend toward greater aggregation in later versions of RRPM. The greater aggregation appears in the regression equations for calculating support and space costs. This greater aggregation is in contrast to the great disaggregation found in MSAR, where all equations are used to calculate lab assistants as a function of discipline, number of student's contract, and type of instruction. One could raise questions concerning the availability and validity of the estimation coefficients as well as the benefit-cost ratio of having the additional equation. It would therefore be interesting to follow-up the experience of MSAR in this respect.

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1) For detailed empirical studies of instability of the ICLM data, see Jewett et al., and Hussain et al.

2) For this and other criticisms of large models see Hopkins (1969 and 1971), and for a response to it see Andrew (1971).

COMPARISON OF OTHER LOGICAL DIFFERENCES

	CAMPUS	HIS	MSAR	RRPM	TUSS
Level of detail	activity (except CAMPUS VII)	activity	activity	discipline	activity
Planning variables	many	few	few	few	few
Standard output	excellent	adequate	adequate	adequate	very good in cluding thos for operatio management
Special modules and features	Faculty flow Revenue Budget Review (CAMPUS IX)	Faculty Optimal Assignment, Capacity Room Assignment, Student Assignment (national)			Output repor on "what-if" questions
				Training game: RRPM 1.35 RRPM 1.6	Training gam USG

COMPARISON OF OTHER LOGICAL DIFFERENCES

	CAMPUS	HIS	MSAR	RRPM	TUSS
	activity (except CAMPUS VII)	activity	activity	discipline	activity
	many	few	few	few	few
	excellent	adequate	adequate	adequate	very good including those for operational management
	Faculty flow Revenue Budget Review (CAMPUS IX)	Faculty Optimal Assignment, Capacity Room Assignment, Student Assignment (national)			Output reporting on "what-if" questions
				Training game: RRPM 1.35 RRPM 1.6	Training game: USG

disaggregated at the course or activity level. Andrew (1973) and others, while recognizing that the aggregate model is valuable for a new and growing institution, argue that it is the disaggregated model at the activity level that is essential for a mature institution. It enables the understanding of the relationship between "constraints and control variables and time and that the system provides information along the continuum from the most disaggregate unit to the most aggregate level of planning".

Another deliberate design difference among the models concerns calculations by the model using existing inventories. RRPM and TUSS have no such calculations and assume no inventory to start with. The comparison of required resources with existing inventories is done manually. This is traded-off against having to keep updated inventory files or enter inventory data to the model. This is a design decision.

The other set of important differences concern special modules and features. Some of these have limited application. For example, the Capacity Module so important to HIS has limited use in the U.S., except perhaps in some professional schools with an under-capacity. Other modules and features have general applicability: the Faculty Flow Module of CAMPUS VII; the Budget Review Module of CAMPUS IX; the Optimal Faculty Assignment Module of HIS; the output capability for "what-if" type questions in TUSS; and the gaming module of both RRPM and TUSS.

There are some logical differences that are not mentioned in any of the comparison figures. Examples are: the three hierarchical structures of staff with ranks within each level in HIS; and the calculation of faculty overtime in MSAR. These calculations are unique to the model environment but could nonetheless be of interest to many a model builder.

4. NON-LOGICAL DIFFERENCES

Other differences in the models concern planning factors, maximum dimensions and technical data. These are compared in Figures 6.4, 6.5, and 6.6 respectively, for the models HIS, MSAR and TUSS. These figures correspond in format to similar comparisons made for CAMPUS and RRPM. The similar format will enable comparisons across all five models.

Figure 6.4

SOME PLANNING FACTORS IN HIS, MSAR AND TUSS

	HIS	MSAR	TUSS
INSTRUCTIONAL			
Student programs	by detailed course activity mix	course	activity
	resource loading of each activity by . space . personnel	. equipment . space . personnel	. space . personnel
	section size: . average . maximum	. average . maximum	. maximum
Faculty	assignment:		
	. module in version A	. substitution policy	. linked allocation model
	. average salaries by rank	. average salaries	. average salaries
	. rank distribution	. rank distribution	
	. workload weights		
SPACE	. utilization	. utilization	. utilization
	. type . size	. type . size	. type
		equipment availability	

MAXIMUM DIMENSIONS OF HIS, MSAR AND TUSS

	HIS		MSAR	TUSS
	A	B		
Student programs	6	120	240	40
Academic disciplines or departments (teaching cost centres)	20	110	25	20
Non-academic departments (non-teaching cost centres)	0	0	0	10
Activities	200	300	2150	400 (groups)
Course levels	(implicit in activity specification)			
Instruction type	5	100	3	
Student levels	14	14	6	7
Faculty ranks	12	12	3	4
Non-academic ranks or classifications	0	0	0	4
Space type and size ranges				
. academic	9	9	30	4
. non-academic	0	0	20	3
Non-personnel				
. resource types	0	0	0	8

Figure

SOME TECHNICAL DATA FOR HIS, MSAR AND TUSS

	HIS		MSAR	TUSS
	A	B		
Program language used	FORTRAN	FORTRAN	FORTRAN	FORTRAN
Equipment used	IBM 360	IBM 360	IBM 360/40	CONTROL DATA CYBER 73
Minimum core requirements (thousand bytes)	more than 256	256	512	164K (binary work)
Cost of software	0	0	--	
purchase				
lease				
Consulting services for overall project management, training of senior staff and adaptation of planning manuals		The cost will vary between 0-25,000 and is expected to be largely for the development of an institutional data base	Developed and used internally	

5. SUMMARY AND CONCLUSIONS

The models of resource allocation being discussed have many common characteristics: they are cost models and not cost-benefit models; they are simulation models not optimising models; they have mostly linear equations for calculating their non-salary costs (when this is done) and thus ignore discontinuities; the models do not predict the number of new entrants to the institution nor do they relate it to manpower requirements; and finally, all are deterministic models (except for the probability matrix used in the student flow module).

From the viewpoint of helping implement and use the model, none of the models provide help in formulating the support (non-salary) cost equations nor in calculating the cost coefficients. Also, no help is provided in studying and improving the stability of parameters especially the ICLM. On use of terminals, some work has been done with CAMPUS and RRPM 1.3 but not enough work has been done on the economics and feasibility of using the model to respond to "what-if" questions in the on-line-real-time mode. Also, no help is provided to the user in searching through the very large set of permutations of possible alternative strategies (both before running the model and after the model is run). Search routines for identifying "promising" and near optimal strategies will greatly help the user. Even the current output will help the user if it is packaged with graphics that show "trends" and "gradients" rather than a mass of sheets of paper. Reports should be designed that also help in "management by exception" so as to identify information and variations that exceed allowable levels. Finally, the models do not enable the user to calculate trade-offs directly. For example, if one wishes to find the trade-offs between average section size and faculty load which keep the cost constant, one has to guess at pairs of values, calculate the costs, and then plot an iso-cost curve (as done in Figure 2.13). This can be both costly in computer time and slow in response time.

Many of the above limitations are largely technological and no doubt can be overcome. New versions and additional modules are being developed and many of the limitations listed above are being relaxed. But the conceptual problems are the difficult ones with little immediate hope in sight. Examples are the problems of benefit identification and measurement as well as cost allocation rules. Finally, there is the problem with the user: his knowing the model; his knowing how to use it and how not to use it; and finally, an appreciation of the model's capabilities and its limitations. There is no need for work in all these areas if allocation models are to be used effectively and widely in higher education.

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PART TWO

INTRODUCTION

The models discussed in previous chapters all use the programmed approach to planning and budgeting. This approach is also used without formal models. Hence it is desirable to examine its assumptions, its relevance and its limitations. This is done in Chapter 7, the first chapter in Part Two.

The rest of Part Two is concerned with projects and models related to resource allocation models. These are surveyed in Chapter 8. Two projects, the Data Element Dictionary and the Programme Classification Structure, are particularly crucial to models using the program approach. These are discussed in detail in this chapter. Other projects and models are briefly mentioned.

A separate chapter (Chapter 9) is devoted to models on cost and costing because of their increasing importance and complexity.

The chapters in Part Two are all designed independently of each other. A knowledgeable or uninterested reader may skip a chapter without much loss of continuity. However, Chapter 6 is a prerequisite for reading Chapter 7 on the programmed approach. Also, it is desirable to scan over Chapter 2, or else be well acquainted with the American educational environment and terms like credit-hours and FTE.

Chapter 7

WHY PLANNING, PROGRAMMING, BUDGETING SYSTEMS FOR HIGHER EDUCATION?*

by

James Farmer

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1. THE PROBLEM

Many college and university presidents are facing the decision of implementing planning, programming, and budgeting systems. The decision to use such a system requires a significant commitment of resources with an uncertain return. It requires the allocation of already limited analytic talent. And there are a few cases of fully satisfied users.

At the same time, there is increasing demand from public agencies and private advisors that PPBS, as it is often called, be immediately implemented(1). Several state colleges and universities are facing requirements by state legislators or finance departments to report in program budget formats. Are these demands reasonable?

Clearly, PPBS must improve the decision-making process markedly to make the investment in PPBS and the related management technology viable. PPBS must, as it requires of the programs themselves, pass the test of cost-effectiveness(2).

2. THE NEW ENVIRONMENT

It is important to understand the "new environment" of higher education in order to understand the motivation of those outside the higher education community to strongly support PPBS. First, higher education is now competing with many significant social problems for funds. Second, higher education is now a closed economic system - there are no independent institutions. Third, there has been an acceptance and use of program budgeting by the federal, state, and local governments, and by business.

For many years higher education has presented the "bill" for higher education to the public for support, and it usually was paid. Now, however, bond authorizations are frequently defeated at the polls, and state governments are drastically reducing per student funds(3). Although higher education used only 2.2 per cent of the

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1) For an example, see the Legislative Analyst's Report, California Joint Budget Committee (Ref.1, p.417). For comments on congressional concern, see Steiner in Novick (Ref.2, pp.314-316).

2) For a theoretical discussion of the economic value of an information (decision-making) system, see Marschak's model (Ref.3 and 4).

3) For a California example, see the Governor's 1970-71 budget goals for the California State Colleges in Ref.5.

billion. By 1980 higher education will be consuming 2.5 per cent of the GNP - some $32.5 billion (1967 dollars)(1). The public now has a large number of social programs - hunger, housing, medical care, transportation, and pollution - competing for public funds. Educators are being asked to specifically describe their objectives, measure their performance, and determine costs.

The public could readily understand one of higher education's arguments - that education was an investment in the economic future of the community. Hirsch described this objective saying:

> ... education is an investment designed to produce an enterprising and skilled labor force that can be counted on to contribute to economic growth, prosperity, technological advances, and national security. Education enables people to hold rewarding jobs and in turn provides the nation with economic and military strength(2).

But in the "search for relevance", students are turning from engineering, medicine and business to ethnic studies, social science, and political science. The public appears to have difficulty finding a direct relationship between these studies and any economic goals cited by the institutions.

It is reasonable that public representatives should now ask for program budgets hoping to get an explicit statement of objectives, measures of effectiveness, and costs by program.

Higher education is now a closed economic system in two senses. First, no institution is completely independent of another. Enrollment and funding of almost all institutions are determined, in part, by the actions of other institutions. This dependence is most evident in the large systems. For example, as the University of California and the California State Colleges began to deny admission to entering freshmen and sophomores, the California Community Colleges had an enrollment surge which would never have been projected by historical statistics. Several states have begun to fund education at private institutions, and almost all institutions, or their students, receive funds from the federal government. Thus, planning must include the effects of these dependencies as well as historical patterns of enrollment and funding.

In a second sense, colleges and universities are considered an integral part of the community's social and industrial base. Some colleges have been created to provide the "technology" for a community's industry, or in an attempt to cause social change. The institution of higher education must then be considered in the context of the economic and social system. The planning system must represent this close interrelationship.

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1) These data, based on 1967 constant dollars, were taken from Tickton, Ref.6, p.22.

2) Ref.2, pp.180-182.

able by business, higher education could have avoided PPBS. But this management technology, developed from science, engineering, and economics, is proving its usefulness. Failing to implement this technology and at the same time failing to articulate its inapplicability, higher education, as a whole, appears to be resistant to change - the very "change" that such institutions are expected to foster. While it is clear to the systems analyst that higher education presents difficult conceptual problems, the reluctance of institutions to approach such planning technology appears unwarranted.

Perhaps Hirsch was more bold than understanding when he said:

> The existing budget and budgeting procedures are so patently uninformative that they effectively conceal most of the needed insight. Many old-timers are quite comfortable in such a situation, which makes it difficult for any operation to be judged and evaluated seriously(1).

Fear of the unknown policy changes which may be imposed on institutions using program budgeting may be the greatest deterrent to its use(2). No organization can be comfortable when there is a re-examination of basic objectives and an evaluation of institutional performance.

Already, however, institutional objectives are being challenged by students, faculty, and the public. Institutional effectiveness is being questioned by the government, foundations, and private donors. Clearly there will be changes, yet there are few sincere explorations by institutional administrators of the quantitative techniques which offer some hope of planning for these changes. There is also some concern that program budgeting will result in increased federal control. Hirsch commented:

> Effective program budgeting by the U.S. Office of Education could strengthen the hand of this agency not only in relation to other parts of the Federal government concerned with education, but also in relation to state and local government. Program budgeting might force the latter to move in a similar direction, especially if federal aid would include such a direct or indirect requirement(3).

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1) Ref.2, p.205.

2) There is a significant danger from misinterpretation of the data generated from program budgeting. Legislatures and control agencies could impose counter-productive changes through misunderstanding. Adequate presentation and analysis of the data to the public agencies will be particularly important for institutions during the early exploratory phases of a program budget implementation. The problem was not significant for the Department of Defense since most program budgets were classified and hence not publicly available.

3) Ref.2, p.205.

enthusiastic than realistic. Some ten years after program budgeting was implemented on the federal level, virtually no institutions of higher education have viable program budgets. There is little evidence that full program budgeting can be implemented in the next few years.

In this "new environment", however, the higher education community has little choice except to explore PPBS and similar planning systems, or lose their credibility as legitimate managers of a vital social function.

3. DEFINITION OF PPBS

Before continuing, it may be useful to review exactly what PPBS is. In a general sense, PPBS is a system for(1):

- Planning - the selection or identification of the overall, long-range objectives of the organization and the systematic analysis of various courses of action in terms of relative costs and benefits.
- Programming - deciding on the specific courses of action to be followed in carrying out planning decisions.
- Budgeting - translating planning and programming decisions into specific financial plans.

Hence, the PPB system includes major planning functions and uses the budget process for the development of a short range financial plan to implement the planning and programming decisions.

A budget is traditionally viewed as direction to the institution for discharging a fiduciary responsibility - an accounting of funds spent. But such line-item budgets provide little substance for a useful dialogue on the issues of higher education. Although expenditures are divided into classes, say wages and salaries, operating expenses, equipment, and capital expense, there is little useful comparison to other institutions which have a different mix of output, or to the past because the outputs of higher education are constantly changing. Having neither comparisons nor identifiable program costs, the line-item budget, in its pure form, has little value for management, or for presentation of new programs.

The basic concept of program budgeting is to focus on output and choose the combination of input resources which best accomplishes that output. It is this aspect of program budgeting which perhaps concerns administrators most. Legislatures have frequently tried to

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1) These definitions were taken from the General Accounting Office Glossary, Ref.7. For more general definitions and discussion, see Haggart, et al., especially Sections I, II, and III. Ref.8, or Greenhouse in Ref.9.

is generally unsuccessful and uncomfortable because resources are not related to specific programs. Using program budgeting, the administrators are expected to understand and accept mutually agreed upon objectives and then expend the funds on whatever mix of resources best accomplishes those objectives. "Fiscal flexibility" is a requisite for management under PPBS. There are several assumptions implicit in a program budget. These should be specifically noted:

- That management has the authority to choose the course of action, or alternative, to accomplish the stated objectives, and has the responsibility for choosing the best course of action. The program budget is not a mechanism for enforcing a predetermined course of action, but rather of identifying the level of available resources made available to accomplish program objectives.
- Planning and programming are a systematic process which can formulate resource requirements for alternative courses of action and compare these courses in terms of the objectives.

In practice these assumptions are violated to some extent, and at some point, program budgets can become an exercise rather than a useful management tool.

Planning and programming - a two step decision process - represent the substance of PPBS. Budgeting is the mechanism for implementation and control, not for basic decision-making. Planning requires a specific statement of institutional objectives, the development of alternative courses of action, and an analysis of these alternatives. Planning requires creativity in order to provide innovative alternatives and requires a well developed analytic capability to adequately analyze the results of these alternatives. Programming requires a detailed understanding of these courses of action in order to provide specific time schedules, coordination with other institutional programs and identification of the personnel, material, and financial resources to be used.

Thus PPBS is not merely a technique but rather represents an organization of people and equipment applying a technology to the management of an institution. An organization using PPBS must place responsibility for the four steps of PPBS - Planning, Programming, Budgeting, and Control - with specific organizational units, provide the procedures for their interrelationship, and be dedicated to management of that organization through this specific process. The technology provides methods of measurement, analysis, and presentation. It is not a system but rather a component. The technology rests with the individuals having specific competence, not with computers, forms or organizational charts.

Only when PPBS is viewed as a management method - an organization and its procedures - is it possible to view PPBS in the proper perspective.

4. DEFICIENCIES OF PPBS FOR HIGHER EDUCATION

There are significant conceptual problems in implementing PPBS for institutions of higher education. First, it is difficult to identify the outputs of higher education. Some analysts have used degree winners, number of courses completed, or student credit hours as output proxies. Others, concerned with the economic value of an education, have used salary differentials between entrance and exit to the institution. None are fully satisfactory and most fail to consider the "quality" of education.

It may be even more difficult to define research output, or the results of public service. The lack of quantitative measures of output is the most severe handicap for implementing PPBS in higher education(1).

Second, there is no single organizational unit which produces a unique output. The physics department, for example, does not itself produce a physics degree. Other departments contribute to that output. Similarly, the physics department expends resources on non-physics majors. Program budgeting techniques are applied with less difficulty when organizational units contribute to a single, measurable output.

Third, production functions for higher education are not known. While there has been considerable research on the education process, there has been no accepted algorithm for determining the resource requirements for a unit of output. Thus, higher education is not fully amenable to the formal economic analysis applicable to business. Also, the output of higher education - research and instruction - are frequently joint outputs, and the resources are used jointly - as, for example, instructors and graduate students working on research - without a clear distinction between their contributions.

5. USES OF PPBS

If PPBS has so many deficiences, is it useful for higher education? While that question should be answered in the context of the specific institution, PPBS does have significant potential for institutional management.

Three examples are given here. The first example will use PPBS data to develop a five-year budget for a growing state college adding

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1) For a discussion of the problem, see Keller, Ref.10.

an engineering curriculum. Both line-item and program budget formats are given. The second example illustrates how a shift in curricular demand by students affects the various departments, although the total resource demand is not significantly changed. The third example uses output results of the first example to examine policy and budget interactions.

Examples such as these must be grossly simplified in order to clearly illustrate the points. However, the data used are similar to actual observations. The results, then, could approximate actual budgets, or policies. However, institutions of higher education are complex and have many driving forces, so such results could not be so readily identified in a real institution.

The first example is an institution of 2,000 FTE students, offering courses in liberal arts and business, and increasing in size about 50 per cent per year. In 1972 an engineering degree program will be initiated(1). The traditional budgeting approach is given in Table 7.1. Average cost per FTE is used to project the total budget. (This is equivalent to giving "workload increases" by increasing the budget proportional to FTE increase.) The total budget is distributed over the traditional line-items - faculty, library, plant operations, support services, student services, financial aid, and other. Usually these categories would be broken down into salaries and wages, operating expenses, equipment, and miscellaneous. There are several implicit assumptions in this budgeting process: (i) all instructional programs require identical resources, (ii) the methods of instruction will not change, and (iii) costs are dependent only on the number of students.

Table 7.2 is a Five-Year Program Budget for the same example. This budget has two significant differences from the line-item budget. Cost estimates are based on FTE students by degree program, recognizing that different degree programs require different resources. Output is specifically identified by FTE student years and degree equivalents. The cost per degree equivalent represents one measure of cost-effectiveness for that institution. The total budget exceeds the estimates of the line-item budget because of the higher cost engineering instructional program. Because of using cost by degree program, the PPBS formulation can be a better estimator of cost than the average FTE cost per year.

The first example showed an institution facing a period of rapid growth which used a simple PPBS concept to develop a five-year cost estimate. But institutions can have rapid changes of degree program

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1) All data are based on the California State Colleges. Cost data is from Ref.11 though values used here may differ somewhat from the final published thesis. Enrollment data are obtained from Ref.12, 13 and 14. The growth rate parallels a new urban state college.

FIVE-YEAR LINE-ITEM BUDGET/GROWING STATE COLLEGE EXAMPLE

		1970	1971	1972	1973	1974
Enrollment, FTE(1)		2,050	3,001	4,393	6,432	9,417
Allocated Cost per FTE		1,160	1,160	1,160	1,160	1,160
Total Budget(2)		2,378,000	3,481,000	5,096,000	7,461,000	10,924,000
Faculty(3)	46.3%	1,101,000	1,612,000	2,359,000	3,454,000	5,058,000
Library	9.5	226,000	331,000	484,000	709,000	1,038,000
Plant Operations	7.9	188,000	275,000	403,000	589,000	863,000
Support Services	20.7	492,000	721,000	1,055,000	1,544,000	2,261,000
Student Services	12.9	307,000	449,070	657,000	962,000	1,409,000
Financial Aid	0.6	14,000	21,000	31,000	45,000	66,000
Other	2.2	52,000	77,000	112,000	164,000	240,000

1) Growth rate of 46.4 per cent per year.

2) 1968 constant dollars - no allowance for price increases.

3) Because of rounding in multiplication, totals may not add. Cost allocations based on Ref.11.

Table 7.2

FIVE-YEAR PROGRAM BUDGET/GROWING STATE COLLEGE EXAMPLE

		1970	1971	1972	1973	1974
Enrollment, FTE		2,050	3,001	4,393	6,432	9,417
Liberal Arts	40%	820	1,200	1,677	2,413	3,447
Business	60%	1,230	1,180	2,516	3,619	5,170
Engineering		-	-	200	400	800
Cost per FTE						
Liberal Arts		800	800	800	800	800
Business		1,400	1,400	1,400	1,400	1,400
Engineering		1,900	1,900	1,900	1,900	1,900
Average		1,160	1,160	1,194	1,206	1,223
Total Budget		2,378,000	3,481,000	5,244,000	7,757,000	11,516,000
Output						
FTE Student Years		2,050	3,001	4,393	6,432	9,417
Degree Productivity Index		.48	.48	.48	.48	.48
Degree Equivalents (4 year)		246	360	527	772	1,130
Cost per Degree Equivalent		9,700	9,700	9,900	10,000	10,200

FIVE-YEAR PROGRAM BUDGET/GROWING STATE COLLEGE EXAMPLE

	1970	1971	1972	1973	1974
	2,050	3,001	4,393	6,432	9,417
40%	820	1,200	1,677	2,413	3,447
60%	1,230	1,180	2,516	3,619	5,170
	-	-	200	400	800
	800	800	800	800	800
	1,400	1,400	1,400	1,400	1,400
	1,900	1,900	1,900	1,900	1,900
	1,160	1,160	1,194	1,206	1,223
	2,378,000	3,481,000	5,244,000	7,757,000	11,516,000
	2,050	3,001	4,393	6,432	9,417
dex	.48	.48	.48	.48	.48
year)	246	360	527	772	1,130
lent	9,700	9,700	9,900	10,000	10,200

identifies the consequences of a change occurring within an institution by the current "search for relevance". In this case some students changed majors from English and history to government and social relations(1).

Table 7.3 shows the enrollment shifts by degree program caused by the changes in student demand. Table 7.4 shows the aggregate cost increments and Table 7.5 gives the traditional line-item display. There are some potential savings from the overall decrease in enrollment, but no significant impact of change is evident.

Table 7.3

DEGREE PROGRAM DEMAND SHIFT/FULL-TIME STUDENTS

Major	1966/67	1968/69	Change	
English	494	367	-127	-26%
Government	446	562	+116	+26%
History	576	422	-154	-27%
Social Relations	337	418	+ 81	+24%
Total	1,853	1,769	- 84	- 3%

Table 7.4

RESOURCE INCREMENT
DEGREE PROGRAM DEMAND SHIFT EXAMPLE

Degree Program	FTE Shifts	Cost per FTE	Dollar Costs
English	-127	$1,472	-187,000
Government	+116	1,859	+216,000
History	-154	2,192	-338,000
Social Relations	+ 81	1,871	+152,000
Total	- 84		-157,000

Table 7.5

LINE-ITEM BUDGET INCREMENTS
DEGREE PROGRAM DEMAND EXAMPLE
(Decrement of 84 FTE)

Budget Category	Per cent	Budget Decrement
Faculty	46.3%	72,000
Library	9.5	15,000
Plant Operations	7.5	12,000
Support Services	20.7	32,000
Student Services	12.9	20,000
Financial Aid	0.6	1,000
Other	2.2	4,000
Total		156,000

---

1) For an example of such an enrollment shift see Ref.15.

These program budgeting systems for higher education have had to relate degree programs (output) to the resources used in academic departments (input). Unlike some other PPBS applications where organizational entities contribute to a unique program, higher education applications have had to develop "cross-over" matrices relating the contribution of departments to degree programs. Weathersby used an induced course load matrix, and Young used a program cost contribution matrix(1). Table 7.6 was prepared using Young's PCCM, and shows the effect on departments as a result of the change in student demand.

The impact on the four major departments - English, government, history, and social relations - is not as significant as would be expected from the dollar cost levels shown in Table 7.4. For example, the loss of 154 history majors, a dollar cost of $338,000, "saves" the history department only $114,000. The remainder of the cost for history majors is in other departments, and the overall impact of the major shifts for the history department is only $87,000 because government majors take a number of history courses. The strong impact on the education department is not evident from traditional analysis. The reduced demand is equivalent to $55,000. Both foreign languages and geography showed some change - $11,000 and $14,000 respectively. It is also interesting to note that the "search for relevance" and the concomitant major changes cause almost no change in the demand for ethnic studies by the students. These kinds of changes are not predictable from line-item budgets, but are clearly evident in PPBS results.

This example showed the resource effects of a change in student demand, a parameter not under the control of institutional administration. These effects are more clearly identified by the program budget format (Table 7.6) than the traditional line-item format (Table 7.5).

There has been no generally accepted measure of the output of higher education. It appears though that any output measure will have several components. Viewing higher education as "immersion" in an intellectual environment, then the number of years attending an institution can be used as a measure of "exposure". Viewing higher education as a series of courses contributing to knowledge, then the number of courses, weekly class hours, or some similar unit becomes a measure. Viewing higher education as progress toward a degree, then the number of degrees awarded becomes a measure of output. Whatever output measure is finally developed and accepted, it will probably have components similar to those listed. It can be useful, however, to look at the consequences of using these measures of output.

---

1) For the Weathersby formulation, see Ref.16, pp.20-28. For the Program Cost Contribution Matrix at San Fernando Valley State College, see Ref.11. Springer, in Ref.17, describes the relationship between the two formulations.

RESOURCE IMPLICATIONS BY ACADEMIC DEPARTMENT(1)

Degree Program	English	Government	History	Social Relations	Total
	-127 FTE	+116	-154	+81	-84
Department					
Education	-30,000	+14,000	-60,000	+21,000	-55,000
Art, Music and Drama	-13,000	+12,000	-15,000	+10,000	-6,000
Foreign Languages	-10,000	+7,000	-12,000	+4,000	-11,000
Geography	-3,000	+6,000	-20,000	+3,000	-14,000
English	-83,000	+12,000	-23,000	+7,000	-87,000
History	0	+22,000	-114,000	+5,000	-87,000
Government	-2,000	+70,000	-15,000	+3,000	+56,000
Social Relations	-3,000	+5,000	-5,000	56,000	+53,000
Ethnic Studies(2)	-2,000	+2,000	-4,000	+5,000	+1,000
Other(3)	-41,000	+66,000	-68,000	+38,000	-5,000
Total	-187,000	+216,000	-336,000	+152,000	-156,000

1) Program contribution coefficients from Ref.11.

2) Ethnic studies department included to show the small increase, caused by "the search for relevance".

3) Seventeen departments showed a change of less than $5,000 each, and totalled only - $5,000.

[illegible] degrees as an output, it is useful to consider the amount of resources minimally required for a degree as compared to the amount of resources actually used to produce a degree. The resulting coefficient could be a measure of effectiveness and might be called a degree productivity index. It appears that the national average for undergraduate education is somewhere between 0.40 and 0.50(1). That is, an institution must produce some 250 to 300 weekly credit hours in order to produce an undergraduate degree.

Using this degree productivity index, the degree equivalents were computed for the first example and shown in Table 7.2. The cost-benefit ratio was then expressed in cost per degree equivalent.

Using the data from the first example, consider alternative policies for a budget constrained institution. Assume that the state college was limited to $3,000,000 for 1971, and that unit costs given apply. The theoretical enrollment mixes are shown in Figure 7.1. With a $3 million budget, the enrollment can vary from 3,750 - all liberal arts students - to 2,143 - all business students. Not all theoretical mixes may be achieved, and many are undesirable even under a constrained budget. Most institutions would elect to accept all returning students. This would mean that 820 business students and 615 liberal arts students returned, and maximum enrollment of 3,135 would be achieved by accepting 1,700 liberal arts students. Several enrollment policies and the resulting number of students which could be accommodated are given in Table 7.7. Although it may not be possible, because of faculty and facilities, to change enrollment policies and mix of student majors abruptly, it is interesting to note the wide variances in the number of students which can be accommodated as a function of their choice of discipline. The question of whether 3,750 liberal arts students are "better" than 2,143 business students is one which unfortunately must be answered with current constrained budgets.

This example can also be extended to show the effects of the degree productive index. Figure 7.2 shows the cost for an engineering degree as a function of the degree productive index. This cost varies from $38,000 per degree at 0.2 to $9,500 at 0.8. For the first example, a productive index of 0.48 yielded a cost of $15,000 per degree.

If degrees rather than number of student courses is the criteria, then counseling and guidance, and remedial or supplementary training

---

1) It is interesting to note that the data to compute this value, even on a gross national basis is not available. This estimate for 1966 was made using Tables 157 and 165 of Ref.13 to estimate undergraduate FTE as a function of head count, and Table 162 to estimate the number of degrees/FTE. This was corrected for a four-year program yielding about 0.48. Using Ref.12, the estimated value for the California State Colleges would be between 0.5 and 0.8 depending on the amount of transfer credit from junior colleges.

POSSIBLE ENROLLMENTS, CONSTRAINED BUDGET

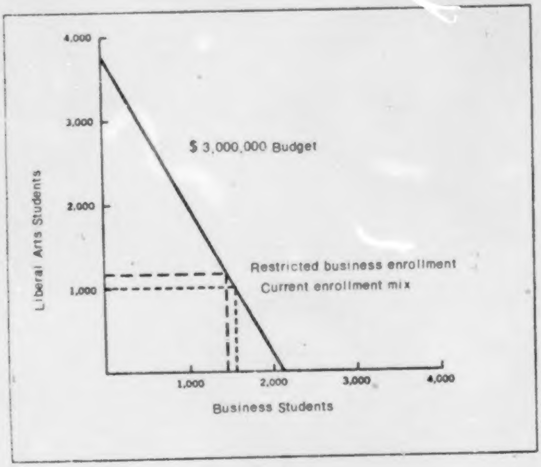
Policy	Liberal Arts	Business	Total
Maximum student enrollment	3,750	0	3,750
Maximum new student enrollment	2,315	820	3,135
Restricted business enrollment	1,200	1,451	2,651
Traditional mix	1,034	1,551	2,585
Maximum business	0	2,143	2,143

may be very important to reduce the average cost per degree. With this measure of output, or this measure in conjunction with exposure or number of courses taken, a direct dollar value for these student services can be derived as a function of the change in the degree productive index.

These examples were intended to illustrate some of the types of analysis which are possible using program budgeting techniques. Many significant variables have been omitted, and all of the conditions illustrated would be operating simultaneously. Furthermore these examples did not show the effects of time and transition. Such factors as faculty tenure and specialized facilities and equipment may cause either increased institutional costs through a transition period, or constrain the alternatives available to the institution.

Figure 7.1

POSSIBLE ENROLLMENT MIXES CONSTRAINED BUDGET



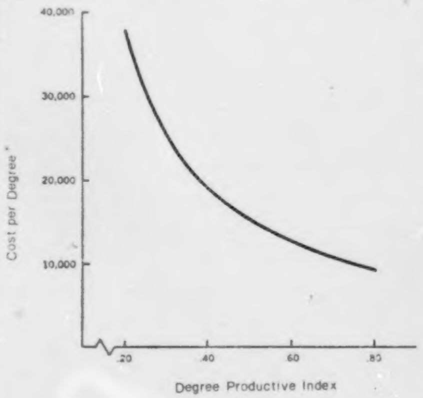
The line-item budget cannot, itself, be used to reflect the resource requirements caused by these changes, or to project resource requirements into the future since it does not relate input to output. The line-item budget and "workload" increases have many assumptions of linearity and small incremental change, and may, because of their structure, preclude change in the mix of organizational activities or methods of instruction or research. While institutions with line-item budgets have had to cope with change, it has been done on an ad hoc basis exogenous to the budget process.

6. IMPLEMENTING PPBS

If an institution elects to be a participant rather than an interested spectator, there are several levels of participation. These include special planning studies using PPBS techniques, an evolutionary implementation which supplements traditional planning methods with PPBS-type studies and parallels the current budgeting system with a program budget, or a "turn-key" conversion to PPBS with the concomitant changes in procedure and organization. Since PPBS may lead to significant organization change, it may be advantageous for an institution to progress through the levels of participation until, through evolution, a full PPBS system has been installed.

Figure 7.2

COST PER ENGINEERING DEGREE



* Based on $ 1,900 per year for a four-year degree program.

some data processing service, and an organization policy of implementation. The organization must include the functions of planning, programming, budgeting, and evaluation. These may be combined into a single PPBS unit, separated into two or more organizational units, or delegated to existing organizational units. The technology resides in the analytic talent of the professional staff, and the success of the PPBS approach correlates highly with the quality of this talent. Some data processing service is necessary to use the quantitative management techniques. Also automatic data processing significantly reduces the cost and improves the timeliness of the PPBS system by having machine readable data bases.

A vital component of an operable PPBS is an organization policy which demonstrates that decision-makers intend to use the results of PPBS. If the results are ignored, the system loses its credibility, and with that loss, its support.

As a method of implementation, a planning studies unit could perform special planning studies to tackle significant problems and to give the staff an opportunity to learn about the technology as well as the results. There is a serious constraint on such studies. Since no change has been made in the reporting system, data base, or organization, the necessary data may not be available for the specific problems given to the planning studies unit.

The PPBS could also be implemented by creating a Vice-President for Planning or a similar position. A planning office, a program office, a budgeting office, and an evaluation or audit office could be set up, and all planning responsibility given to that vice-president. Concurrent with this organizational change, an information system should be developed to support the data requirements of planning, and procedural changes should be made to implement planning through program-budgeting rather than the traditional procedures. Such a "turn-key" approach requires a significant investment and, frequently, outside assistance.

An evolutionary approach may be better. Program budgets parallel current budget formats using cross-overs. Studies are used to define a single set of organizational objectives, and revised procedures are developed to use program change proposals in lieu of budget justifications. The information system is gradually modified to support the broader data requirements of PPBS. While the evolutionary approach requires additional resources because of parallel operation, it permits the organization to assimilate PPBS technology.

Again, the question of implementing PPBS can be answered only in the context of a specific organization. The purpose here was to point out that there are different routes for implementing PPBS, and the institution should choose the one most likely to produce results.

Perhaps an overlooked advantage of the PPBS technology is the better understanding of the real nature of the art of management. Robert Hayes said:

> I believe that the greatest impact of the quantitative approach will not be in the area of problem solving, although it will have a growing usefulness there. Its greatest impact will be on problem formulation: the way managers think about their problems - how they size them up, bring new insights to bear on them, relate them to other problems, communicate with other people about them, and gather information for analyzing them. In this sense, the results that "quantitative people" have produced are beginning to contribute in a really significant way to the art of management(1).

This improvement may be the most significant value of PPBS.

Frederick dew Bolman, describing the administrator as a leader and statesman, admonished:

> The college and university administrator must know not only how to assess his institution in financial terms with unit costs and program budgeting analyses. He must learn ... cost-benefit analysis. This is an educator's task ... What hard evidence have we to present to the federal government, state legislatures, corporations, and individuals that we are really effective and efficient?(2)

In summary, then PPBS can be viewed two ways. As a system for planning and control, PPBS may be expensive and difficult to implement. Thus, an institution should be rightfully cautious in trusting its future to an abrupt implementation of PPBS. But the technology associated with PPBS may significantly improve the art of management by improved insight into the higher education process. For this reason, an administrator would be negligent if he did not invest in the time to learn about PPBS and its technology.

8. SUMMARY

Planning, programming, budgeting systems require extensive investment on the part of institutions of higher education. But there is pressure, from public agencies and the public in general, for

---

1) Ref.13, p.108.

2) Ref.14, p.182.

management. The "new environment" for higher education includes competition with other social programs for funds, an inter-dependent economic system, and the acceptance of PPBS by federal, state, and local governments, and by business.

However, PPBS has several conceptual deficiencies when applied to institutions of higher education. There has been no fully satisfactory definition of the output of higher education. In institutions there is no single organizational unit which produces a unique output - a graduate is the product of many different academic departments and the recipient of many different services. There are no accepted production functions for higher education, and because of the joint input and output of programs like research and instruction, production functions for higher education will be difficult to identify or quantify.

A PPBS formulation can, however, provide additional insight into program changes by identifying resource requirements; and developing costs by program tends to improve understanding of objectives and outputs. Several examples are given.

Three methods of implementing PPBS are listed: planning studies, evolutionary development of PPBS, and the "turn-key" changeover to PPBS. This paper concludes that an institution should begin implementation of PPBS cautiously, but that the PPBS technology would be useful to college administrators in developing their management art.

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Chapter 8

PLANNING RELATED MODELS AND PROJECTS

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1. DATA ELEMENT DICTIONARY

A Data Element Dictionary (DED) defines every data element and identifies other relevant information. In the case of a DED used for operational systems, the other information required will concern its storage and validity such as format, validity rules, etc. Such a DED has been developed by the Hochschul Informations System (HIS) for institutions in West Germany. This DED will later be extended for use in models and use at higher levels of decision-making. In the U.S., the approach has been different. The DEDs needed by institutions for their internal management has been left entirely to the institutions. However, data elements that are required or may be required for models that will be used for generating information for inter-institutional comparisons have been defined in DEDs developed by NCHEMS - the National Center for Higher Education Management Systems in the U.S. These DEDs will later be made compatible with other DEDs developed at the statewide level (Topping & Miyataki, 1972; and NCHEMS, 1970).

The DEDs developed by NCHEMS and now in its second edition (Goddard, et al., 1973) has 215 data elements. They are organized as follows:

Student data	70
Course (classes) data	34
Staff data	64
Finance data	13
Facilities data	34
Total Data Elements	215

A page from one of the DEDs developed by NCHEMS is shown in Figure 8.1. It is worth noting that the DED not only defines the data element and identifies its subclassifications, but also identifies the planning models that will most likely use that data element. In the example of Figure 8.1, the model CFP (among others) is a potential user of the data element defined (CFP is the acronym for the Cost Finding Principles Project). This identification of model users of each data element is very valuable when building a data base that will eventually use such models.

One set of data elements that appears in all DEDs (except the Student DED) is the Program identifier and the Program Category Identifier. These are part of the Program Classification Structure - the next topic.

006
ELEMENT NUMBER

National Center for Higher Education Management Systems

DATA ELEMENT DICTIONARY
Finance Related Data Elements

ELEMENT TITLE: Object Classification

DEFINITION

The classification of expenditures according to the nature of the cost incurred.

CODES OR RECORDING INSTRUCTIONS

The Cost Finding Principles Project currently is considering the following categories:

Code	Category	Definition
10	Faculty Salaries	Compensation including fringe benefits to those individuals that the institution considers its faculty (part-time and full-time faculty as well as graduate assistants).
20	Nonfaculty Salaries	Compensation including fringe benefits paid to all employees of the institution except those considered faculty.
30	Supplies and Services	All current operating expenditures other than compensation for personal services (including fringe benefits), expenditures for capital equipment, and stipends.
40	Capital Equipment	Those items of property that have an acquisition cost of $200 or more and an expected service life that exceeds one year.
50	Stipends	Financial assistance awarded to students (both undergraduate and graduate). Includes scholarships, fellowships, and traineeships. Recipients of stipends are not required to render service to the institution as a consideration of their awards, nor are they required to repay them.

USES: CFP, IEP, PM, HEFM, RRPM, FAA

COMMENTS:

Institutions will usually have more detailed categories within the above groupings.

DATE ISSUED: September 1972

2. PROGRAM CLASSIFICATION CODE

2.1. Introduction

The need for a program classification structure is well stated by Gulko:

> The desire to apply programmatic analysis to budgeting and planning in higher education and the growing need for accountability has identified the need for a structure that will provide a consistent and organized means of classifying all activities of higher education in terms of programs. (Gulko, 1972:1)

There are some nationally adapted program classification codes. There is one in Canada (Clardel, 1972) and one in the Netherlands. Perhaps the most used is the PCS used in the U.S. (Gulko, 1972).

2.2. Construction of the PCS

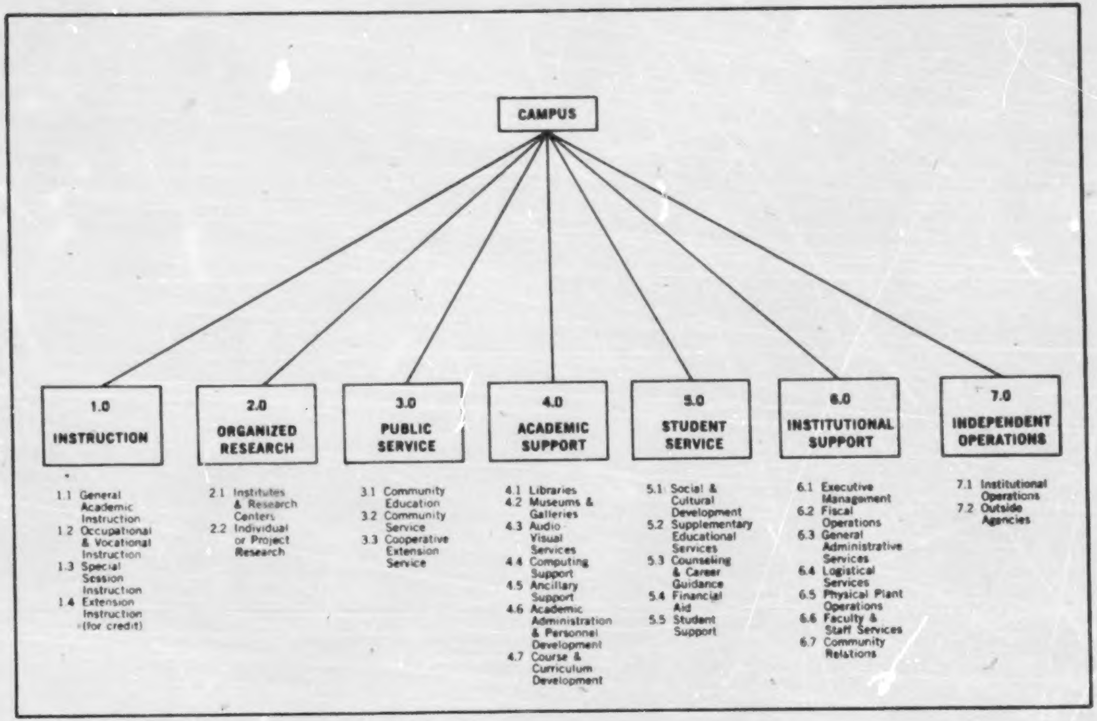
The PCS was developed by the National Center of Higher Education Management Systems (NCHEMS). As with all the products of NCHEMS, the design was done by a national Task Force selected from institutions of higher education and tested by a stratified sample of pilot institutions for validity and generality. It was also tested by pilot institutions implementing other NCHEMS products such as the RRPM (Resource Prediction Model), the CFP (Cost Finding Principles Project), etc. Comments and critiques were solicited from the over 2,500 institutions of higher learning in the U.S. and were reviewed regionally and nationally by all interested groups such as statewide and national agencies as well as academic professional organizations. The modified PCS, after three years of development, was released in 1972 (Gulko, 1972). It is currently being revised for special problems including those raised by vocational and trade institutions.

2.3. The Structure of the PCS

The PCS classifies programs (the NCHEMS terminology for programs) into one of three primary programs or one of four support programs. Each has sub-programs with a total of 30 sub-programs. These are shown in Figure 8.2 (Gulko, 1972:19).

The PCS has six levels of classification. These are shown in Figure 8.3 (Gulko, 1972:21). The lowest is a program element which is then associated with descriptors called program measures which enable each program element (and its aggregations) to be related to the "resources utilized, activities level generated, groups served, expenditures incurred, revenues generated and outcomes achieved", (Topping, 1972). This data provides us with a production function for each program and enables program planning and program budgeting.

ORGANISATION OF THE PROGRAM CLASSIFICATION STRUCTURE


CAMPUS
1.0
INSTRUCTION
2.0
ORGANIZED RESEARCH
3.0
PUBLIC SERVICE
4.0
ACADEMIC SUPPORT
5.0
STUDENT SERVICE
6.0
INSTITUTIONAL SUPPORT
7.0
INDEPENDENT OPERATIONS
1.1 General Academic Instruction
1.2 Occupational & Vocational Instruction
1.3 Special Session Instruction
1.4 Extension Instruction (for credit)
2.1 Institutes & Research Centers
2.2 Individual or Project Research
3.1 Community Education
3.2 Community Service
3.3 Cooperative Extension Service
4.1 Libraries
4.2 Museums & Galleries
4.3 Audio Visual Services
4.4 Computing Support
4.5 Ancillary Support
4.6 Academic Administration & Personnel Development
4.7 Course & Curriculum Development
5.1 Social & Cultural Development
5.2 Supplementary Educational Services
5.3 Counseling & Career Guidance
5.4 Financial Aid
5.5 Student Support
6.1 Executive Management
6.2 Fiscal Operations
6.3 General Administrative Services
6.4 Logistical Services
6.5 Physical Plant Operations
6.6 Faculty & Staff Services
6.7 Community Relations
7.1 Institutional Operations
7.2 Outside Agencies

PROGRAM CLASSIFICATION STRUCTURE NOMENCLATURE

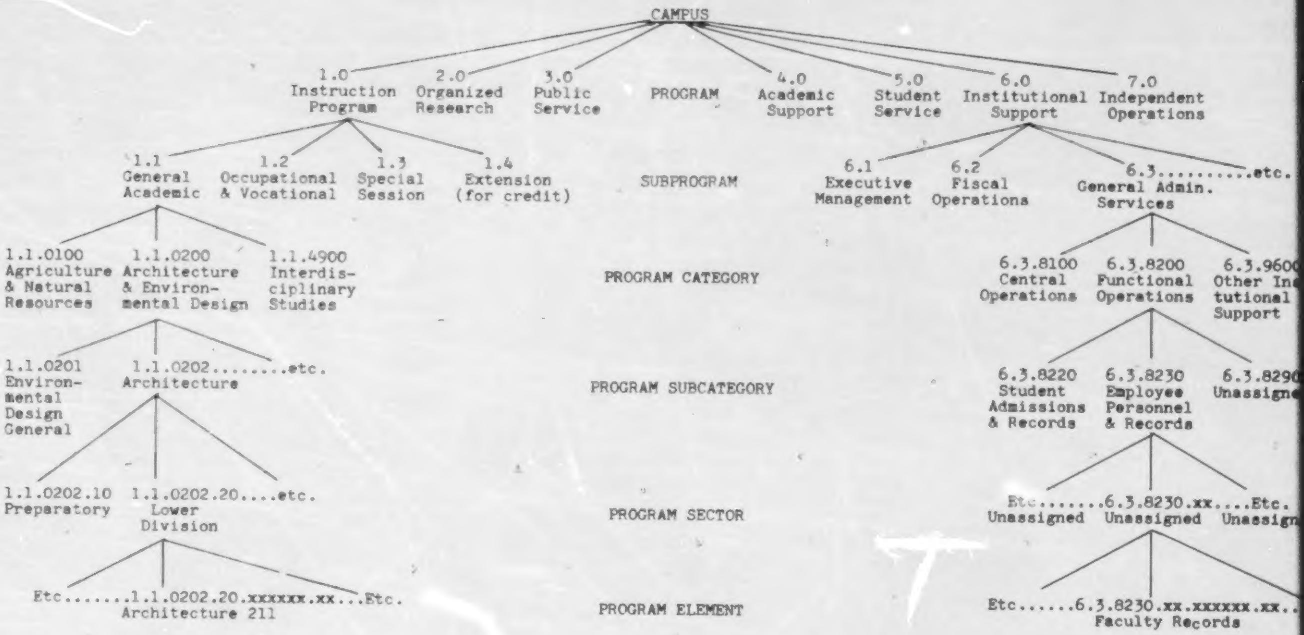
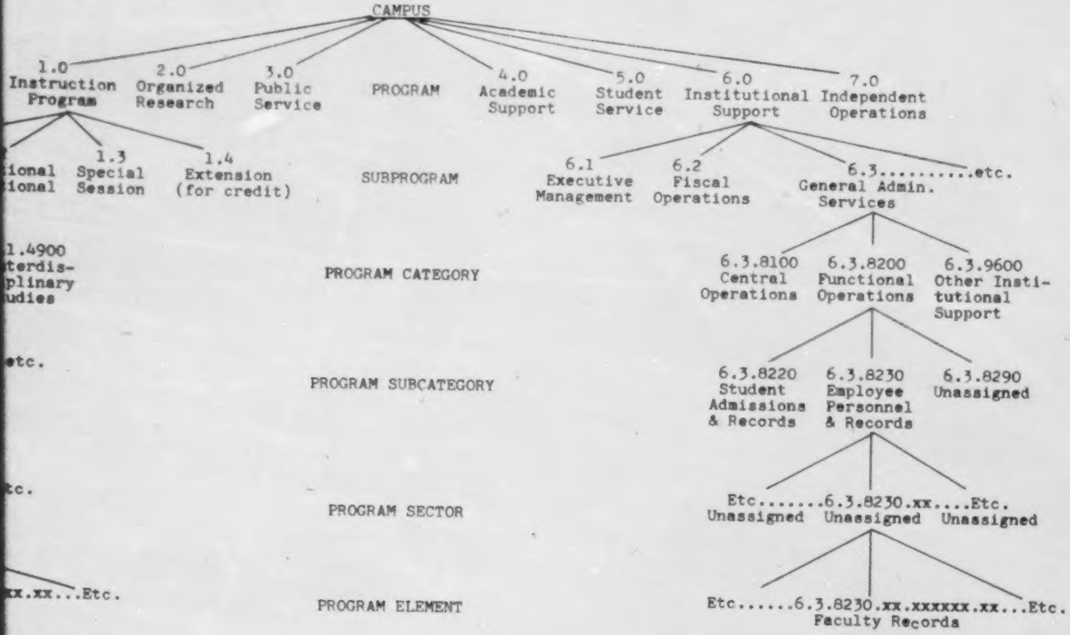

CAMPUS
1.0 Instruction Program
2.0 Organized Research
3.0 Public Service
PROGRAM
4.0 Academic Support
5.0 Student Service
6.0 Institutional Support
7.0 Independent Operations
1.1 General Academic
1.2 Occupational & Vocational
1.3 Special Session
1.4 Extension (for credit)
SUBPROGRAM
6.1 Executive Management
6.2 Fiscal Operations
6.3.........etc.
General Admin. Services
1.1.0100 Agriculture & Natural Resources
1.1.0200 Architecture & Environmental Design
1.1.4900 Interdisciplinary Studies
PROGRAM CATEGORY
6.3.8100 Central Operations
6.3.8200 Functional Operations
6.3.960 Other In tutional Support
1.1.0201 Environmental Design General
1.1.0202........etc.
Architecture
PROGRAM SUBCATEGORY
6.3.8220 Student Admissions & Records
6.3.8230 Employee Personnel & Records
6.3.829 Unassign
1.1.0202.10 Preparatory
1.1.0202.20....etc.
Lower Division
PROGRAM SECTOR
Etc.......6.3.8230.xx....Etc.
Unassigned
Unassigned
Unassign
Etc.......1.1.0202.20.xxxxxx.xx...Etc.
Architecture 211
PROGRAM ELEMENT
Etc......6.3.8230.xx.xxxxxx.xx..
Faculty Records

Figure 6.3

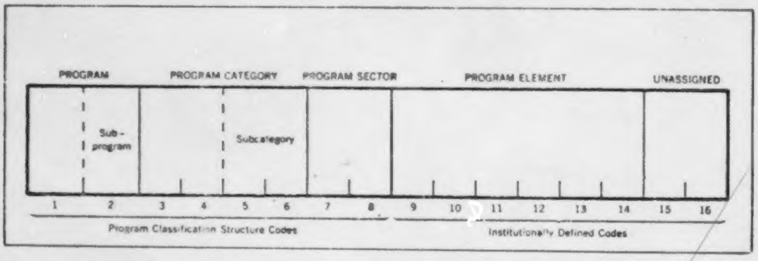
PROGRAM CLASSIFICATION STRUCTURE NOMENCLATURE


CAMPUS
1.0 Instruction Program
2.0 Organized Research
3.0 Public Service
PROGRAM
4.0 Academic Support
5.0 Student Service
6.0 Institutional Support
7.0 Independent Operations
ional
ional
1.3 Special Session
1.4 Extension (for credit)
SUBPROGRAM
6.1 Executive Management
6.2 Fiscal Operations
6.3..........etc.
General Admin. Services
1.4900
terdis-
plinary
udies
PROGRAM CATEGORY
6.3.8100 Central Operations
6.3.8200 Functional Operations
6.3.9600 Other Institutional Support
etc.
PROGRAM SUBCATEGORY
6.3.8220 Student Admissions & Records
6.3.8230 Employee Personnel & Records
6.3.8290 Unassigned
tc.
PROGRAM SECTOR
Etc.......6.3.8230.xx....Etc.
Unassigned
Unassigned
Unassigned
xx.xx...Etc.
PROGRAM ELEMENT
Etc......6.3.8230.xx.xxxxxx.xx...Etc.
Faculty Records

The PCS in its code format is shown in Figure 8.4 (Gulko, 1972:26). The program categories and subcategories of the PCS incorporate a classification long used by the national government in the U.S. for annual reporting by all institutions of higher education. This classification, known as HEGIS (Higher Education General Information Survey), was revised by yet another project of NCHEMS (HEGIS VIII) and subsumed in the PCS.

Figure 8.4

CODING STRUCTURE FOR THE PCS


PROGRAM
PROGRAM CATEGORY
PROGRAM SECTOR
PROGRAM ELEMENT
UNASSIGNED
Sub-program
Subcategory
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Program Classification Structure Codes
Institutionally Defined Codes

3. STUDENT MODELS

All resource allocation models require data on the number of students in each program by level of student. This can be determined by a student flow model given projections of new student entrants.

Student flow models are sometimes part of the resource allocation model as discussed in Chapter 6. Examples of the models discussed were CAMPUS, HIS, RRPM and TUSS. Another allocation model that also has a student flow module is SEARCH. Most of these models are designed to use other student flow models with little interfacing because there are many such models developed elsewhere.

A study done by Lovell (1971) identified 19 such models. Some worth mentioning are: Young and Almond (1961), Gani (1963), Stone (1965), Oliver (1968), Perl and Katzman (1968), Caspar (1969), Oliver and Marshall (1969), the Working Group for Empirical Research (Freytag et al., 1969), Casper (1969), Dietze (1969), Sandell (1971), Marshall, Oliver and Suslow (1970), Newton (1970), Smith (1970) and Turksen (1970).

The student flow models require as input the new enrollment. This can be done by an enrollment projection model which typically is a regression equation(1). But the need for such projections has greatly decreased in Europe where numerus clausus is being increasingly evoked, and students are assigned to specific institutions(2).

4. SPACE ANALYSIS

One reason for numerus clausus is the limitations of physical capacities. This requires that one calculates the physical capacity given utilization factors. These factors need to be defined along with procedures for determining them and analysing them. Often space is typically used by more than one program and the space resource consumed has to be allocated to these programs. The allocation rules have to be stated. These rules are important for calculating unit costs and operating budgets. But in addition, we need rules for projecting space needs, for this determines the capital budget.

There are many manuals for space analysis. One is the Higher Education Facilities Planning and Management Manual (HEFPMM)(1) developed by NCHEMS in the U.S. (Dahnke et al., 1971). Another is an updated version of the HEFPMM incorporating the experience of users. It is the Facilities Inventory Classification Manual (FICM)(3), also developed by NCHEMS (Romney, 1972). Other space studies are the Space Planning and Cost Estimation (SPACE) simulation model developer at the University of California in Berkeley and the Institutional Space Inventory Techniques (INSITE) developed at MIT.

5. FACULTY ACTIVITY ANALYSIS

An important component of costs is the faculty. Associating its costs to different programs is a difficult problem since a faculty

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1) For an empirical comparison of projection techniques, see Orwing, Jones and Lenning (1972).

2) For decision rules and procedures in Sweden, see MacMurray, et al., (1969), and for Germany, see Böckling (1973).

3) These models have been identified by their acronym because the acronym will be used later in a Survey Study.

member is a typical joint-product between more than one program. The question is how should the faculty's costs be allocated? Should they be in proportion to how the budget allocates its funds; or should the costs be in proportion to the activity expended for each program? Or perhaps a weighted function? Or perhaps in proportion to some other rule? (Romney, 1971). These are problems of cost principles.

6. PROCEDURES FOR FACULTY ACTIVITY ANALYSIS

Once cost principles have been decided upon, we then have a problem of procedures, especially when the rule chosen is the proportion of time spent by faculty. The problem is how to determine this time spent. Should the faculty be asked to state the proportions or should the department chairmen be asked? Or perhaps both? And how should the effort be determined: in hours spent or percentages of total week work-load? These questions have been raised by many institutional researchers over the years. A survey (Romney, 1971) identifies 44 research studies that were almost evenly split on the technique of determining effort. But there is a need for concensus as to an acceptable method. One attempt is a project by NCHEMS (Baugham et al., 1972). It will test a set of forms and procedures and hopefully it will be generally accepted.

The need for procedures and principles of costing was long recognised in the United States and was one of the most important reasons for the founding of NCHEMS. It is a task that is now in progress (Manning and Romney, 1973).

7. MANPOWER ACCOUNTING MANUAL

A project related to faculty activity analysis is the development of a classification of manpower in higher education including faculty. This has been done in the U.S. in the manual called Manpower Accounting in Higher Education (Minter, 1972). This manual "arranges personnel categories by occupational activities rather than by job titles. This arrangement allows for the proration of job positions to one or more of the occupational activities, which in turn can be described by the responsibility associated with each task". A related project is the classification of higher education employees by assignment (Minter, 1971).

8. BUDGET MANUAL

The projections for budgetary line-items must be made according to specific guidelines and procedures. Specific documents must then be generated that will display and summarize information according to desired format and nomenclature. All these are stated in a Budget Manual.

One such manual is being developed by NCHEMS. Meanwhile, there are many recorded examples of the use of such manuals and models in the United States (Balderston and Weathersby, 1972; Weathersby and Balderston, 1972); in Canada (Marshall, 1968); and in Sweden (Hammar, 1968; Appelquist, 1971).

9. COST IDENTIFICATION AND COSTING PRINCIPLES

The first step to costing is the identification of cost components and cost elements. In some cases there are problems. For example, consider the acquisition of a book by a department. Who should it be charged to? The department? Or the library? The choice may seem inconsequential for an institution, but it is important if costs are compared between institutions. Then it becomes necessary to define each cost component precisely.

Once cost items are identified and costs are determined then there is a problem of allocating costs to the users. For example, let us continue with our example of the library. How should the library expenses be allocated? In proportion to the students or faculty in each program? Or should it be in proportion to the books used or number of users of students and faculty? (If an answer is yes, this raises problems of measurement!) Or should it be in proportion to the academic level of programs using the library? Or perhaps a weighted function of all these variables? If yes, then what are the weights?

A computer program has been developed by NCHEMS for experimenting with different weights and different variables (Beatty, G.,Jr.,1972). Using this program to simulate, different allocation rules should help identify relationships that are politically acceptable and economically reasonable. These rules could then be used in Resource and Cost Models such as CAMPUS and RRPM.

There is much work done in the area of cost principles, and costing: in the United States (Ziemer et al., 1971); in England at Bradford (Bottomley, 1972); and at the OECD (Legg, 1971).

Costing information as well as other planning information is often required for exchange between institutions. The information could be used for planning, say, of a new degree, already offered by another similar institution. However, before this can be done it is necessary that such information be exchangeable between institutions. There is another reason for comparability. It is desired by agencies above the institution. They require such information not only for evaluating and assessing accountability, but also for purposes of planning at its level. The output of the institution becomes the input for the higher level agencies. In multiple institution planning it is necessary that the information is comparable for all the institutions involved. Hence, the need for comparable information.

In order that comparable data can be exchanged and used for higher level planning, it is necessary to agree on principles and procedures of exchange as well as the content of information to be exchanged. This would include the identification of data and its deviations (coefficients and indices) that need to be exchanged; the determination of the levels of aggregation; and the formats for reporting.

11. BENEFIT/COST MODELS

The models discussed thus far are related to resource or cost models. They do not calculate the benefit/cost ratios of any program. This is not because this is not desired, but because we are unable to do so. We do not have the technology to measure the outcomes, benefits and performance of education. And this is not because of a lack of effort. Much work has been done on this subject both in the United States (Keller, 1969, Lawrence et al., eds., 1970) and in Europe, on returns to education (Psacharopoulos and Hinchliffe, 1973). This is an area of great importance and the subject of study by a national Task Force at NCHEMS in the United States (Micek et al., 1974).

12. OTHER MODELS

There are other models related to planning(1). Some of these can be used independently of a resource allocation model such as

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1) For an excellent survey of all planning-related educational models in Europe, see OECD (1969, (a), (b) and (c)). For a survey of educational models in the U.S., see Schroeder (1973).

iii), or the Higher Education Planning System (HEPS) which provides a wide range of planning data on such matters as future program loads, class sections, space needs, and space scheduling (Shoemaker, 1973:(i)). There are other models that can be used in conjunction with an allocation model such as the scheduling of students (Oakford et al., 1967; Tomer, 1969); models that calculate capacities (Redelberger, 1969; Bessai et al., 1969; Finkenstaedt et al., 1972; Rumpf, 1969; Heckenhausen, 1968; Mahrenholtz and Withum, 1969; as well as Menges and Elstermann, 1970); and faculty flow models (for a survey of such models, see Higby, et al., 1974).

13. USE OF MODELS AND PROJECTS

Many of the models and projects discussed above have been developed at institutions both in the U.S. and Europe. But in two countries an effort has been made to develop an integrated set of models and projects related to planning, budgeting and management. One such effort is by NCHEMS in the U.S. and is shown in Figure 8.5. Another is the work by HIS - Hochschul Information System - in West Germany. It is shown in Figure 8.6. HIS has done less on modelling perhaps because it has concentrated on developing functional data files and functional applications, an area left to the institutions in the U.S.

A number of these models and projects have been implemented either individually or collectively (Huff et al., 1974). One survey done by NCHEMS in late 1973 covered 1,295 institutions in the U.S. and 16 institutions abroad. One set of results are shown in Figure 8.7 (NCHEMS, 1973:15).

The survey includes the use of resource allocation models such as RRPM discussed in Part One. It also includes CEM, a version of RRPM used as a game for training and the ICLM generator, a subset of many a resource allocation model but used widely for projecting course requirements.

Analysis of data not displayed in Figure 8.7 showed that there was a correlation between type of institutions and use of models. The larger the size and the higher the level of degrees offered, the greater the use of models. For example, RRPM was used by 22.2 per cent of masters and doctoral institutions with 5,000 or more students as compared to 9.7 per cent of all institutions. Another observation was that many institutions used models but not necessarily those implemented by NCHEMS. For example, among users of the ICLM generator, only 50.3 per cent used the NCHEMS product.

Planning-Related Models and Projects

- Data oriented projects
  - Data Element Dictionaries*
  - PCS*
  - HEGIS*
  - Program Measures
  - Manpower Accounting Manual*
  - Classification for higher Education Employees by assignment*
  - Higher Education Finance Manual*
- Institutional Planning Models/projects
  - Resource Allocation*
  - Student Flow*
  - Cost oriented
    - -Cost Finding Principles*
    - -Faculty Activity Analysis Procedures*
    - -Faculty Activity Analysis Manual
  - Outcomes Planning Project*
  - Future Planning and Management
- Institutional Analysis
  - Student Flow Analysis
  - Space Analysis*
  - Program Budget Manual
  - Cost Exchange Procedures
- Departmental Analysis
  - Resource Utilisation Analysis
  - Departmental Management System
  - PROBE PROgram Budget Estimation
- Statewide Planning
  - PCS
  - Data Element Dictionary
  - Resource Prediction Model
  - Student Flow Model
- National Planning
  - Resource Planning
  - Federal Financing of Higher Education
  - National Foundation for Post-Secondary Education
- Training
  - Seminar
  - Games*

Note: * Completed at least once as of June 1973.

ning-Related Models and Projects

- nstitutional nalysis
  - Student Flow Analysis
  - Space Analysis*
  - Program Budget Manual
  - Cost Exchange Procedures
- Departmental Analysis
  - Resource Utilisation Analysis
  - Departmental Management System
  - PROBE PROgram Budget Estimation
- Statewide Planning
  - PCS
  - Data Element Dictionary
  - Resource Prediction Model
  - Student Flow Model
- National Planning
  - Resource Planning
  - Federal Financing of Higher Education
  - National Foundation for Post-Secondary Education
- Training
  - Seminars*
  - Games*

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of June 1973.

MODELS AND PROJECTS AT HIS (GERMANY)

Planning-Related Models and Projects

- Institutional Data Files
  - Student File*
  - Course and Instruction File
  - Personnel File
  - Finance File*
  - Space File*
  - Property Inventory File
- Data-Related Projects
  - Key data File
  - Standards
  - Data Element Dictionaries*
  - Data Management System (IMS) pilot study
- Planning Models
  - Capacity Models*
  - Capacity Model for Medical Facilities
  - Faculty Activity Analysis
  - Resource prediction Model A and B*
  - Optimal Faculty Assignment*
- Institutional Management Models
  - Room, Class & Student Scheduling*
  - Manpower Forecasting
  - Optimal Academic Organisation
  - Sampling Report Generator
- National Models
  - Student Allocation*
- Research Projects
- Training Program
  - For Mana
    Administ
  - In-house
    Technica
    Training

Note: * Completed at least once as of June 1973.

MODELS AND PROJECTS AT HIS (GERMANY)

Planning-Related Models and Projects

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Manage-
System
pilot

Planning Models
- Capacity Models*
- Capacity Model for Medical Facilities
- Faculty Activity Analysis
- Resource prediction Model A and B*
- Optimal Faculty Assignment*

Institutional Management Models
- Room, Class & Student Scheduling*
- Manpower Forecasting
- Optimal Academic Organisation
- Sampling Report Generator

National Models
- Student Allocation*

Research Projects

Training Program
- For Management Administrators*
- In-house Technical Training*

least once as of June 1973.

NUMBER AND PER CENT OF RESPONDING INSTITUTIONS ANSWERING "YES"

	Number of U.S. Institutions Listed in NCFPE(1) Data Base	Total No. of Institutions Responding	No. of Foreign Institutions Responding	Have Used NCHEMS Data Element Dictionary	Have Used NCHEMS Program Classification Structure For:			Have Built an Induced Course Load Matrix	Have Done a Cost Study	Have Used NCHEMS Software:			Have Used NCHEMS Cost Simulation Model for Projective Purpose	Have Used FICM and/or HEFPMM (3)	Have Used Manpower Accounting Manual
					Finance Data	Student Data	Course Data			ICLM Generator	RRPM 1.6 or CEM(2)	Cost Finding Principles			
All Institutions Per cent	2,946	1,311	16	484 36.9%	401 30.6%	445 33.9%	453 34.6%	354 27.0%	236 18.0%	178 13.6%	127 9.7%	70 5.3%	88 6.7%	476 36.3%	163 12.4%
Public Institutions Per cent	1,410	768	15	363 47.3%	303 39.5%	332 43.2%	358 46.6%	254 33.1%	161 21.0%	144 18.8%	101 13.2%	54 7.0%	66 8.6%	318 41.4%	104 13.5%
Private Institutions Per cent	1,536	543	1	121 22.3%	98 18.0%	113 20.8%	95 17.5%	100 18.4%	75 13.8%	34 6.3%	26 4.8%	16 2.9%	22 4.0%	158 29.1%	59 10.9%
Community Colleges Per cent	1,114	418	2	116 27.8%	131 31.3%	139 33.3%	156 37.3%	72 17.2%	55 13.2%	39 9.3%	28 6.7%	17 4.1%	25 6.0%	124 29.7%	33 7.9%
Institutions Offering the Baccalaureate Degree Per cent	797	324	1	69 21.3%	61 18.8%	76 23.5%	67 20.7%	55 17.0%	38 11.7%	17 5.2%	15 4.6%	7 2.2%	8 2.5%	107 33.0%	35 10.8%
Institutions Offering the Master's Degree Per cent	658	305	1	139 45.6%	111 36.4%	109 35.7%	116 38.0%	102 33.4%	67 22.0%	53 17.4%	41 13.4%	19 6.2%	22 7.2%	106 34.8%	50 16.4%
Institutions Offering the Doctoral Degree Per cent	377	264	12	165 62.5%	101 38.3%	124 47.0%	118 44.7%	129 48.9%	79 39.9%	73 27.6%	45 17.1%	28 10.6%	33 12.5%	143 54.2%	46 17.4%
Institutions with Enrollments under 2,000 Per cent	1,915	635	3	116 18.3%	132 20.8%	150 23.6%	143 22.5%	82 12.9%	65 10.2%	25 3.9%	24 3.8%	8 1.3%	18 2.8%	170 26.8%	51 8.0%
Institutions with Enrollments of 2,000-4,999 Per cent	509	272	2	113 41.5%	87 32.0%	97 35.7%	102 37.5%	84 30.9%	45 16.5%	42 15.4%	24 8.8%	15 5.5%	19 7.0%	109 40.1%	30 11.0%
Institutions with Enrollments of 5,000-9,999 Per cent	294	206	4	127 61.7%	103 50.0%	99 48.1%	113 54.9%	86 41.7%	64 31.1%	51 24.8%	37 18.0%	23 11.2%	26 12.6%	101 49.0%	50 24.3%
Institutions with Enrollments 10,000-19,999 Per cent	148	126	6	85 67.5%	55 43.7%	64 50.8%	68 54.0%	74 58.7%	42 33.3%	41 32.5%	29 23.0%	17 13.5%	18 14.3%	61 48.4%	20 15.9%
Institutions with Enrollments of 20,000 or more Per cent	80	72	1	53 73.6%	31 43.1%	43 59.7%	37 51.4%	35 48.6%	24 33.3%	23 31.9%	16 22.2%	8 11.1%	7 9.7%	42 58.3%	13 18.1%

1) The National Commission on the Financing of Post-secondary Education developed a data base for use by Commission staff members, parts of which were made available to NCHEMS. The figures shown in this column are U.S. institutions only, while those shown in the remaining columns included foreign institutions that responded to the survey.

2) Resource Requirements Prediction Model (RRPM) 1.6 or Cost Estimation Model (CEM).

3) Facilities Inventory and Classification Manual (FICM) or Higher Education Facilities Planning and Management Manuals (HEFPMM).

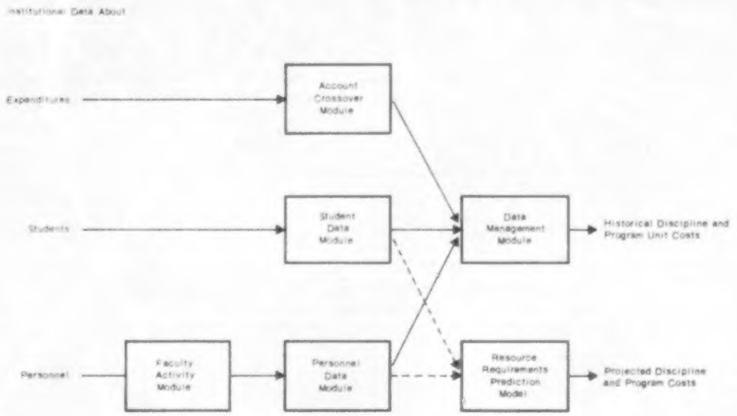
The survey does not reflect any changes in user preference or priorities. But a shift is reflected in the development and implementation work being done by NCHEMS. Originally, back in 1969, the emphasis was on resource allocation in the RRPM model with cost and costing more as a spin-off but certainly having a secondary role. Now, however, the costing model is of primary importance with resource allocation as a possible extension. This is reflected in the flow shown in Figure 8.8 where the dashed lines represent a possible extension of the main model which generates costing information to be used for exchange between institutions within the country under the Information Exchange Procedures (IEP) project.

The IEP project had its pilot test in 1973 with 70 institutions selected on a stratified basis to represent all types of institutions in the country: state funded colleges and universities, private institutions and community colleges (Collard et al., 1974). The project was then tested not only for the NCHEMS packaged software as illustrated in Figure 8.8, but also the NCHEMS definitions and methodology. The results of the pilot test will result in improved information exchange procedures to be released in 1975.

The shifting interest towards costing is partly because of the demands made by funding agencies for cost data which is used for control, prediction and even in some cases as a basis of future funding. Costing data is also being used increasingly by institutional management. It is because of this increased interest and importance of cost and costing that the subject will be discussed in great detail in the next chapter.

Figure 8.8

NCHEMS COSTING AND DATA MANAGEMENT SYSTEM


Institutional Data About
Expenditures
Account Crossover Module
Students
Student Data Module
Data Management Module
Historical Discipline and Program Unit Costs
Personnel
Faculty Activity Module
Personnel Data Module
Resource Requirements Prediction Model
Projected Discipline and Program Costs

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Chapter 9

WHY COST ANALYSIS FOR HIGHER EDUCATION(1)

by

James Farmer

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1. INTRODUCTION

1.1. Need for Analysis

As budgetary constraints, increasing enrollments, pressures for institutional diversity, and demands for improved program quality continue in higher education, college and university administrators have slowly introduced the techniques of planning and management technology into budget analysis. Although higher education is an extremely complex and subtle process, there is now general consensus that these techniques can be useful. Also, that most of the current educational planning and management tools based on cost identification and estimation may not be totally satisfactory. Such models as the NCHEMS Cost Estimation Model (CEM) and Resource Requirements Prediction Model (RRPM) have been primarily used to develop unit costs, rather than evaluate alternatives for institutional planning.

There is an emerging feeling that the identification and estimation of benefits will become tractable in the near future(1). At the same time, both analysts and administrators are becoming acutely aware of practical difficulties as they gain experience in higher education; we are building both conceptual insight and a deeper understanding of higher education itself, and will eventually improve both planning and management technology, and the educational process.

This paper focuses on improved definition of the more frequently used terms of cost analysis, rather than the identification of educational benefits, not because of relative importance, but because of the apparent need for better understanding of the potentials of cost analysis.

1.2. Definition of Cost Analysis

Cost analysis can be viewed as the identification of resources used, or estimated to be used, for a project, activity, or product. In higher education, as compared to industrial manufacturing, it is difficult to measure the final "product", and cost analysis consequently refers to an activity (e.g. an hour of classroom instruction) or a project (e.g. a sponsored research project of a "library automation" project) which may be conceptually considered as a set of activities.

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1) See Ref.1 for a recent effort.

The resources most typically used in higher education are faculty and staff time, building space facilities, and educational materials. For example, the resources directly used for a given number of student (semester) credit units can be viewed as eighteen hours of faculty time in the classroom, plus fifty-four hours of faculty time in preparation and consultation, fifteen hours of clerical support, eighteen hours use of a 20 seat classroom, 280 library book days, fifty pages of mimeograph paper, and so on. In the short run these resources cannot really be represented as dollar amounts; in fact, the use of dollars implies an exchange which is not functionally possible. A faculty member cannot be immediately "traded" for mimeograph paper or library books or building space. Thus most models identify faculty time, by discipline and instruction level, as a resource, and only secondarily use dollars as a unit measure of resources expended.

Costs are defined to include not only dollar expenditures, but recognize that if resources are used to provide one type of educational program, they are not available for another, perhaps better, experience. "Economic costs" are benefits lost. In this sense, educational costs are often called "alternative costs", or "opportunity costs", reflecting the value of foregone opportunity. In an economic sense, costs are simply lost benefits, and it follows that costs and benefits have the same quantitative dimensions. Were this not true, it would be impossible to compare costs and benefits - and there would be no basis for systems analysis.

There are two reasons why costs are often thought easier to measure and identify than benefits. First, it is usually simpler to identify dollar estimates of the resources used than of benefits produced. Secondly, from "long tradition and careless habit" all those costs which cannot be conveniently measured in dollar amounts tend to be ignored(1). It is important, therefore, to understand what costs are not considered in normal fiscal analysis. For example, only now are the "social costs" being recognized as a part of the "cost" of industrial production.

Though dollar amounts are identified throughout cost analysis, they are used only as proxy measurements and do not represent "a medium of exchange". With stable budget levels, fixed physical plant, and tenured faculty all mitigating against alternative resources, and a lack of budget flexibility, the opportunity to change the mix of resources in higher education is extremely limited. Unfortunately, this is occurring just at a time when the form and method of higher

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1) This argument is developed in Ref.2, pages 25-27. Fisher further argues that we often transfer any costs that are difficult to measure to the benefit side of the equation, and leave the negative quantities for the benefit analyst to evaluate.

education are changing, and modifications of the mix of resources appear desirable. The user of cost analysis results should be aware that numbers in dollars may seem to represent alternatives which are not, in the real world, available.

There are four possible ways of analyzing costs. First, merely to list the resources required for an activity; second, to identify and describe some alternative uses of these resources (for example, to teach Physics 103 instead of General Science 201, or to use Professor X as a student counselor rather than as an instructor); third, to estimate the value of the alternatives; fourth, to estimate the dollar expenditures that will be incurred by the proposed activity.

All four of these techniques occur in cost analysis, and any of the four may be useful to a decision-maker. The second technique - identifying alternative uses of the resources - requires a certain understanding of the educational process, and a creative input by the cost analyst. It may be the most useful, but it is possibly the least conclusive, particularly in those cases where educational theory is omitted in favor of fiscal expediency. The third procedure - estimating the value of the alternative policies - is the appropriate goal of educational cost analysis.

The difference between cost and budget analyses becomes immediately evident. Budget analysis uses only procedures one and four - the resources for a single alternative are identified, and dollar estimates of the expenditures are made. Cost analysis requires consideration of alternative uses of the resources, and a broader definition of costs. It gives specific consideration to time, uncertainty, and future decisions. Because of the impact of cost analysis, budget analysis is increasingly being viewed in broader terms, and the responsibilities of "cost analysis" are more frequently being borne by those who were traditionally identified as budget analysts.

2. COST DEFINITIONS AND USES OF COST ANALYSIS

2.1. Types of Costs

Cost analysts use a number of different definitions of costs, including labor, material, capital, operating, direct and indirect costs, etc., which have come from accounting, and marginal, average, and total costs, etc., which have come from economic theory. For any specific institutional analysis, it is initially important to distinguish between relevant and irrelevant costs.

Future costs are relevant and historical costs are, by definition, irrelevant. Costs that have been incurred by past decisions are resources expended, and the alternatives no longer exist. Thus, cost analysis always begins from a presently available decision; past costs are "sunk" and therefore irrelevant. Only future or incremental costs (from the present time) are relevant to decision-making.

For purposes of analysis, it is also useful to distinguish between fixed and variable costs. Those costs that change with activity or production rates are called variable costs, and those which do not are identified as fixed costs. In higher education, building construction usually represents a fixed cost while maintenance is variable, dependent upon the number of classrooms, laboratories and square footage used. In one sense, faculty salaries are a fixed cost (they represent a given number of faculty members on contract), but alternatively, they may be viewed as variable (one full-time equivalent faculty member is required for each 180 annual student credit units taught). A graphical example of fixed and variable costs is given in Figure 9.1. Over a reasonably large range of student enrollment, a campus may adjust its operational budget by adding or reducing part-time faculty, and readjusting schedules. For 14,000 students, the California State University, Fullerton's average cost is \$1,712, representing \$1,018 direct instruction and \$694 for other expenses(1). Assuming that direct instruction is variable (over the range of consideration) and other expenses are fixed, the "fixed costs" at CSUF are \$9.79 million and the "variable costs" are \$14.35 million, or \$1,018 per full-time equivalent (FTE) student.

Another important budgetary distinction is between recurring and non-recurring costs. For example, a computer used in a laboratory may have a cost of \$350,000 as a non-recurring expense - for the purchase of the equipment and its installation. But it may also have a recurring cost - say \$10,000 a year - for maintenance service. It may have an additional (and variable) cost - perhaps 46c - for each student job, representing the cost of paper, printing, and operation.

These distinctions are important to cost analysis since time, when a decision is to be made, separates sunk from incremental or future costs; the level of activity, scope, separates variable from fixed costs; the duration of the activity separates recurring from non-recurring costs. Thus, relevant costs are those which may be impacted by a decision to be made, the available alternatives, and the decision time.

In higher education, there is another distinction between costs which should be made, the difference between internal and external costs. Frequently, alternatives have impact on costs which may not be borne by the institution. For example, an instructor may give an assignment and suggest that the students, because of crowded campus library conditions, use the local public libraries. To the extent that students do this, the cost is external. A second example might

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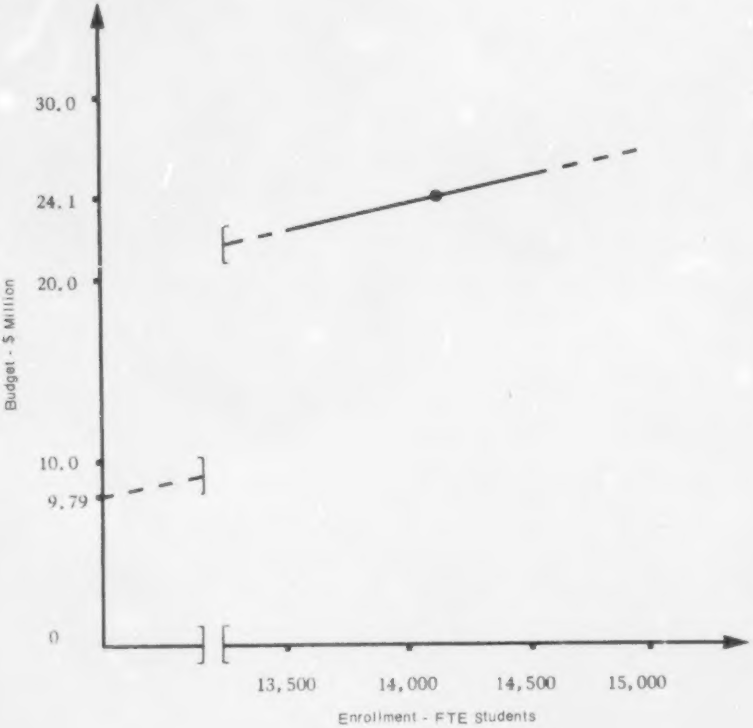
1) Data taken from Ref.3.

INSTITUTIONAL RELATIONSHIPS

CALIFORNIA STATE UNIVERSITY, FULLERTON, 1973-1974



be the development of course materials. When the institution requests a new course from a faculty member already teaching full time, the investment is borne by the instructor as a work overload. It is not assumed by the institution, and is therefore an external cost. External costs, of course, can be relevant, as many administrators encountering difficult relationships with local government can attest.

Figure 9.1 can also be used to illustrate the definitions of marginal, average, and total cost. Assuming that the budget represents actual expenditures, the total costs for 14,100 FTE are $24,136,203 and total costs for 14,101 FTE would be $24,137,221 - a difference of $1,018. The marginal cost - the increment of total cost that comes from producing an increment of one unit - is $1,018, which in this case is also the variable cost. The average cost changed from $1711.79 to $1711.74 representing an "allocation" of five cents of the fixed cost to the next unit. The relationship between total, classification of fixed and variable costs, and assuming that budgeted costs represent actual expenditures. Notice that the marginal cost remains constant, but average cost decreases with increases in enrollment(1). This is referred to as "economies of scale"; unfortunately, economies of scale are more difficult to identify in practice than in theory.

Figure 9.2

MARGINAL AND AVERAGE COSTS,
CALIFORNIA STATE UNIVERSITY, FULLERTON, 1973-74

Enrollment (FTE)	13,600	14,100	14,600
Total Cost	$23,630,000	$24,130,000	$24,648,000
Average Cost	$1,738	$1,711	$1,688
Marginal Cost	$1,018	$1,018	$1,018

A further example of economies of scale is illustrated in Figure 9.3. The unit cost per annual credit hour of engineering classes at California State University, Northridge is shown as a function of class size(2). Assuming a fixed number of students, the number of faculty (and hence faculty salaries per unit) is a function of class size, and determines the variable costs. The total of fixed costs are identical, and have been allocated equally to each of the students.

Another distinction in types of costs, frequently made by accountants, is between direct and indirect. Direct costs are all those product costs traceable either because they are physically visible in the end product, or because they act directly on the product(3). This definition, as taken from the terminology of cost accounting, is not directly applicable to higher education, because of the more complex nature of the "product" involved. But most accountants regard the costs of the teaching faculty, classroom supplies, and materials

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1) In many cases it is possible for an institution to add a few students at the margin with no resulting impact on costs. Revenue derived from these enrollments is consumed in average and total costs, but does not affect the marginal cost. While the addition of X number of students requires a "step-level" response in expenditures, a single student (at the margin) may not. Although early resource models (MICRO-U 70.1) recognized the step-function phenomenon, it has unfortunately been deleted from more recent models. Both CEM and RRPM assume that the cost-revenue relationship is linear, and that the addition of one student will cause the institution additional expense. That is incorrect, and should be appropriately modified in future modeling efforts.

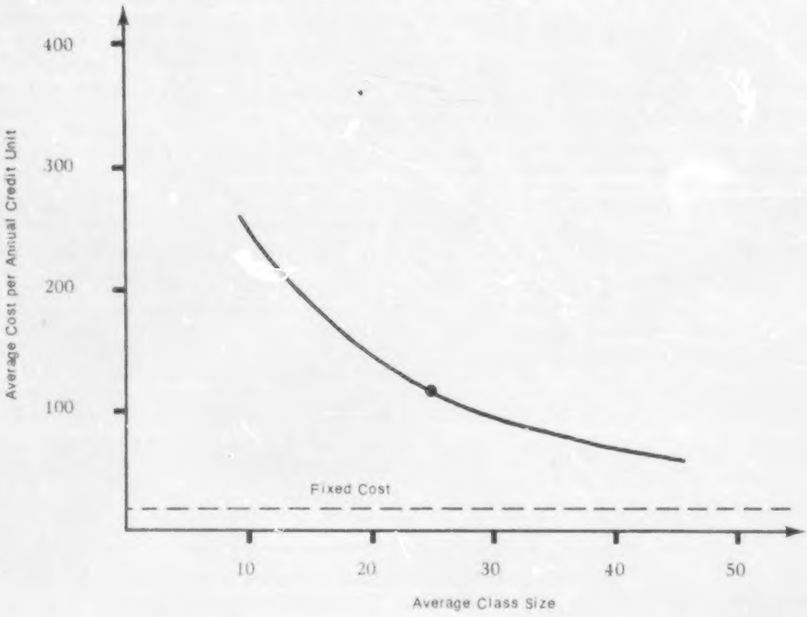
2) Cost data is taken from Ref.4, Chart 10. These data for 1970-71 were produced using the NCHEMS Cost Estimation Model.

3) Ref.5, page 19.

Figure 9.3

AVERAGE UNIT COSTS AS A FUNCTION OF CLASS SIZE

Engineering Department, Lower Division



as direct instructional costs. Similarly, the costs of a research project include "... the salaries and wages of those working on the project, expenditures for equipment and materials used, and other expenses specifically identified with the project(1). The difference between direct and indirect costs is certainly more pragmatic than conceptual. Direct costs are those which an accountant elects to identify with a specific outcome or product, and indirect costs are those which are not so specified, but are "allocated" to the outcome or product in order to achieve an average cost. Hence the distinction comes more from accounting practice than economic theory. While it is reasonable to identify a specific instructor by rank and salary with a class, it is much less reasonable to identify the cost of checking out each library book for each student. The number of transactions and the dollar amount they represent are insignificant to many cost computations.

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1) Ref.6, page 52.

It is useful to identify the difference between cost and budgetary analysis. Unfortunately, budgets are frequently used as the basis for cost analysis, but they are only crude approximations of costs because (1) the expenditures are often not directly related to a budget - many institutions consistently spend amounts markedly different from their budget allocations - (2) only dollar expenditures are included - the induced cost of an alternative is not identified - and (3) aggregations tend to support fiduciary rather than cost accounting - the chart of accounts reflects the requirements of fund accounting rather than those of cost analysis. Additionally, a budget represents a fixed time period, typically a single fiscal year. Yet, because budgets are printed documents, freely available, they are often used as a source of data for cost analysis, instead of the more accurate books of account.

In an effort to make budget and accounting data more applicable for cost analysis and control, many institutions are incorporating program cost accounting into the administrative system. The NCHEMS Program Classification Structure (PCS) shown in Figure 9.4 is most frequently used(1). Employed in conjunction with the traditional classification of fund accounting, the PCS permits both cost identification and fiduciary accounting(2).

In many institutions budgets have typically been prepared as "incremental workload" budgets, and increased in some proportion to utilization - e.g. number of students, and such factors as monetary inflation. Additionally, as certain approved "new programs" are added, they become part of an increased base for subsequent years. Such budgets cannot reflect economies of scale, improvements in quality, or even changes in the type of students. With the advent of program budgets, more detailed cost estimation procedures have been required. Since these are frequently produced by cost analysis, budgets now are beginning to be based on analyses which, in turn, are based on the expenditure patterns as recorded in the accounting schemes. Such NCHEMS models as the Cost Estimation Model (CEM) and Resource Requirements Prediction Model (RRPM) can be used to develop costs to serve as the basis for program budgets.

2.3. Uses of Cost Analysis

There are three principal uses of cost analysis: planning, control, and justification. Cost analysis and estimation provide the

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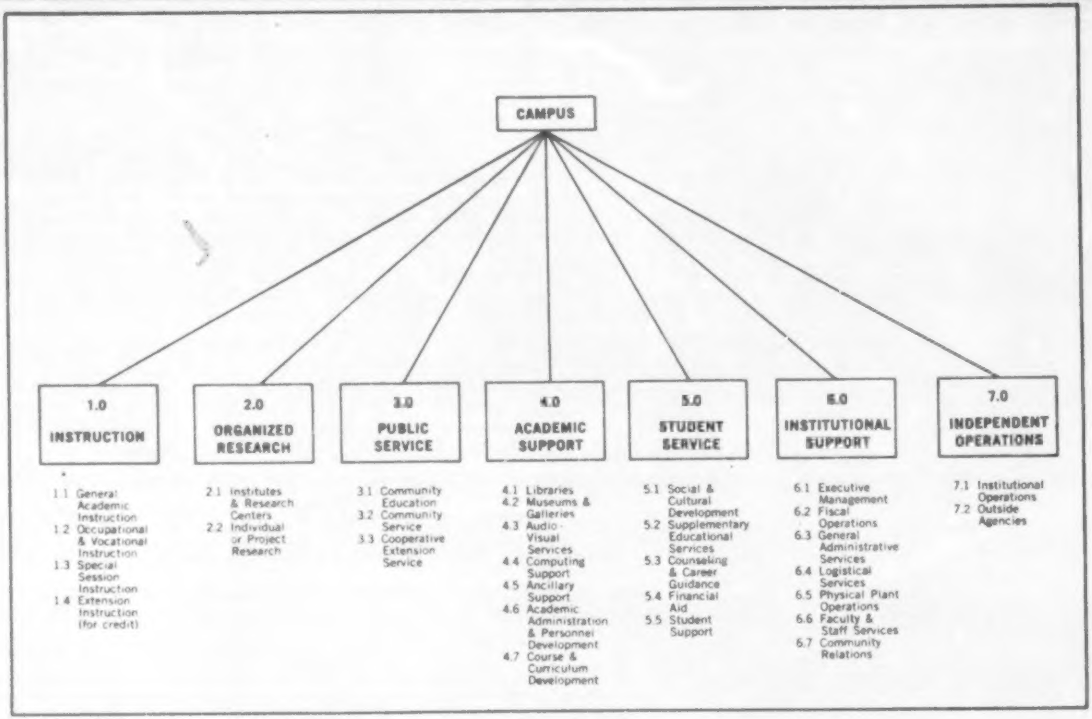
1) For the current version of the NCHEMS PCS, see Ref.7.

2) For the recommended and most frequently used chart of accounts, see Appendix A of Ref.6, pages 223 to 236.


CAMPUS
1.0
INSTRUCTION
2.0
ORGANIZED RESEARCH
3.0
PUBLIC SERVICE
4.0
ACADEMIC SUPPORT
5.0
STUDENT SERVICE
6.0
INSTITUTIONAL SUPPORT
7.0
INDEPENDENT OPERATIONS
1.1 General Academic Instruction
1.2 Occupational & Vocational Instruction
1.3 Special Session Instruction
1.4 Extension Instruction (for credit)
2.1 Institutes & Research Centers
2.2 Individual or Project Research
3.1 Community Education
3.2 Community Service
3.3 Cooperative Extension Service
4.1 Libraries
4.2 Museums & Galleries
4.3 Audio-Visual Services
4.4 Computing Support
4.5 Ancillary Support
4.6 Academic Administration & Personnel Development
4.7 Course & Curriculum Development
5.1 Social & Cultural Development
5.2 Supplementary Educational Services
5.3 Counseling & Career Guidance
5.4 Financial Aid
5.5 Student Support
6.1 Executive Management
6.2 Fiscal Operations
6.3 General Administrative Services
6.4 Logistical Services
6.5 Physical Plant Operations
6.6 Faculty & Staff Services
6.7 Community Relations
7.1 Institutional Operations
7.2 Outside Agencies

alternative choices. Planning and management systems are based on derived cost data and cost estimating relationships. Cost analysis can also be used for institutional control. Excessively large or small costs often identify areas of potential resource misuse or undesirable low quality. As cost finding systems are operated in conjunction with an accounting system, institutional administrators can have immediately available departmental and unit costs. Because the market mechanism in higher education is undeveloped (or non-existent), cost comparisons between similar programs in similar institutions provide some guidance to management.

In order to achieve funding approval for programs in both public and private institutions, justification of the proposed expenditures must be made to either the Executive and Legislature, or board of trustees. Cost analysis organizes and quantifies the resource requirements of the proposed programs in a form most frequently desired by those responsible for the funding decision. Thus cost analysis may provide an effective justification. This benefit of cost analysis may be overlooked(1).

Different users, however, evidence needs for different types of cost data. National and state planning agencies want average unit costs both for planning and control; it is important that their unit costs be classified by level and discipline area for comparability of outcome. Institutions, however, need to know marginal costs since this is what affects short term operation - they are the costs which decision-makers can control in the immediate future. Cost components are important for academic planners inasmuch as they represent the detailed use of resources for the educational process. For example, it may be important to know the amount of resources used by each student for audio-visual, library, computing, and other academic support activities.

Thus the cost analyst compiles data for a given decision, and the definition of "unit" and "costs" is dependent upon the parameters of that decision. On the other hand, accounting procedures provide historically consistent and comparable results, the essence of accounting practices. The definition of "indirect" costs of research has little usefulness for analysis but may allow substantially different amounts of costs to be recovered from the federal government. For example, the indirect cost rate for federal contracts cannot include interest payments; yet colleges, like any other business, may use credit, and that represents a cost to the institution.

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1) These specific uses were suggested by Dr. F.E. Balderston, University of California, in Ref.8, pages 8-9.

Therefore, to have costs which are nationally comparable, it is imperative to have common definitions of output, common classification of expenditures, and common procedures for allocating indirect and direct costs. None of these are necessary for a particular institution's planning.

Cost analysis is used to evaluate different program or policy alternatives for a specific decision at a specific time, and the classifications and techniques used are chosen within the context of that specific decision. Thus, there is a significant conceptual and practical difference between cost finding to provide comparable information and cost analysis to assist decision-making.

3. COSTING IN HIGHER EDUCATION

3.1. Unit Costs and Measures of Output

Higher education, unlike manufacturing, does not have an immediately identifiable output. While it may appear that "a student" is the output of higher education, it is nonetheless obvious that students can be quite different in what they learn. Clearly a student in a liberal arts college is different from one in a vocational program, or a graduate student - they represent pattern differences in the use of resources, the knowledge and growth acquired, and the social (economic) value of the "output".

Both student credit hours, and their aggregations - full-time equivalent (FTE) student, and weighted head count student - are being used as proxies for educational output. Although there are conceptual weaknesses, significant improvement in management information can be made with this simple approximation. Others have suggested degrees granted, but the more complex problems of attrition, transfers, major-changes and program instability have made these computations too difficult for consistent use.

The most frequently used unit cost in higher education is the cost per full-time student. Although there are varying definitions of a full-time (FTE) student, it often is simply a fixed number of student credit units. In California, an FTE represents 15 student-credit units (attempted) regardless of the student level. In other states, the number of semester hours decreases with increased level, representing the reduced credit hour loads of upper division and graduate students. Figure 9 5 shows the cost components of the average cost for a full-time equivalent student at California State University, Fullerton - $1,578 per FTE student(1). Because the NCHEMS Program

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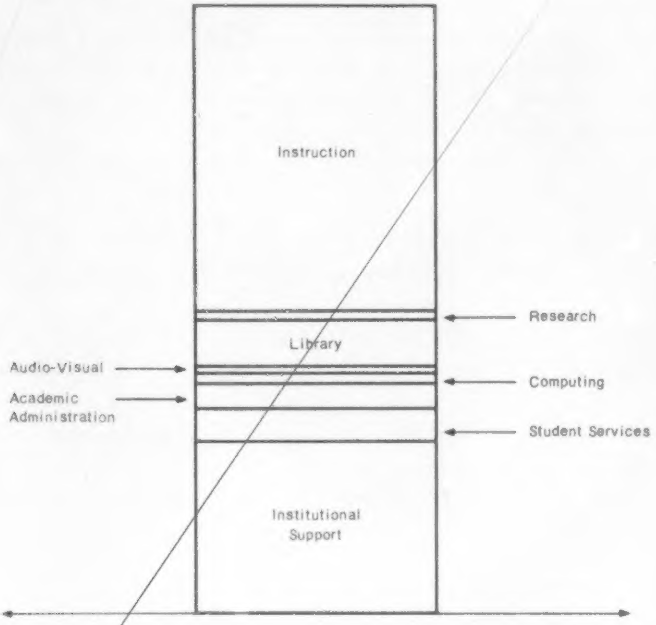
1) These data were taken from Ref.9 and are significantly different from Ref.3. The NCHEMS Pilot included income from all sources. Based on a total budget of $19,395,745 less research, extension division, and special session instruction, the average cost per FTE was $1,578 compared to the published $1,379.

AVERAGE COST COMPONENTS PER FTE STUDENT, CALIFORNIA STATE UNIVERSITY, FULLERTON, 1971-1972



Classification Structure was used to classify expenditures, comparisons of these cost averages could be made between similar institutions having comparable programs and distributions of enrollment between levels and disciplines. Since the latter assumption is almost never satisfied, it is becoming more common to develop costs per annual student credit unit by the particular level and by discipline of instruction.

Both the NCHEMS Cost Estimation Model (CEM) and Resource Requirements Prediction Model (RRPM), and SRG's CAMPUS compute these costs(1). The NCHEMS models essentially derive cost per student credit unit (SCU) by accumulating costs of faculty salaries by level by department, and distributing these and other departmental expenses over the total number of SCU produced by level of instruction. Thus, to develop direct instructional costs, the NCHEMS models merely perform the

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1) For a description of CEM, see Ref.10, RRPM, see Ref.11, and CAMPUS VII, see Ref.12. CAMPUS uses cost per contact hour, but the model can derive costs per credit directly if credit hours are used. For a comparison, see Ref.13, pages 16-22 or Ref.14.

necessary accumulation and distribution of budgeted or projected amounts. Because of the number of levels of instructions, the number of departments, and the number of faculty ranks and salaries, these computations would be impossibly tedious if done manually. Additionally, both CEM and RRPM provide for the allocation of indirect costs using elementary allocation techniques. While these methodologies are appropriate for cost projection, they are inappropriate for either historical cost analysis or cost finding.

Figure 9.6 shows the indirect and direct costs for an annual student credit unit by discipline and by level for selected disciplines. Since costs are significantly different by discipline and level, it is important that such classifications be retained. If there had been no difference between instructional levels then the additional effort of identifying faculty assignments and expenditures by level would not be worthwhile. Figure 9.7 shows comparative full cost data for three California institutions. Some of the differences are readily explained by enrollment levels, and economies of scale; others result from differences in instruction methodology, and differences in the type and quality of instruction. Some arise from different allocation techniques used for indirect costs.

Unit costing can also be used for institutional management and control. An interesting example is an analysis done at the California State University, Northridge, by the Counseling and Testing Center. These results, shown in Figure 9.8, provided some insight into operations of the counseling service. For example, the cost of personal counseling was $79 for each visit, which usually lasted less than one hour. Thus the direct costs of personal counseling in the state college were significantly higher than the average costs (about $50 per hour) of professional services in the community. Two conclusions were made by the counseling staff: there was more professional one-to-one counseling than the students required, and group meetings could permit additional services at reduced per unit costs. (Central State University in Oklahoma uses group sessions with a cost less than $1 per student contact hour.) Clearly, there are subjective judgements which must be made with this type of cost data, but simply identifying the use of resources to responsible administrators can improve the basis for judgements.

As comparisons are made between instructional costs, they can also be made among indirect cost components. Figure 9.9 identifies three cost components for two California state colleges. Even though these institutions have identical budgeting formulas, the amount of resources actually expended varies significantly. In part, this represents the reallocation of resources by the institution, but it also results from difference in the formula allocations for two similar institutions with different enrollments.

AVERAGE COST PER ANNUAL STUDENT CREDIT UNIT

Discipline	Student Level	Direct Instructional	Indirect	Total
Art	L	18.55	18.05	36.60
	U	30.87	24.31	55.18
	G	56.41	36.28	92.69
Business	L	--	--	--
	U	22.11	21.79	43.90
	G	52.15	35.42	87.57
Chemistry	L	29.79	20.03	49.82
	U	73.97	43.10	117.07
	G	181.74	88.58	270.32
Engineering	L	54.51	85.93	140.44
	U	67.61	39.07	106.68
	G	77.86	42.72	120.58
English	L	20.62	19.53	40.15
	U	26.62	22.09	48.71
	G	56.06	34.91	90.97
Mathematics	L	30.07	23.96	54.03
	U	37.45	27.87	65.32
	G	109.24	58.20	167.44
Sociology	L	15.95	16.03	31.98
	U	19.02	17.67	36.69
	G	38.45	26.61	65.06

Figure 9.7

FULL COST PER ANNUAL STUDENT CREDIT UNIT

Discipline	Student Level	State College		Private
		A	B	
Art	L	62	37	177
	U	94	55	177
	G	268	93	
Business	L	53		
	U	51	44	
	G	67	88	
Chemistry	L		50	123
	U		117	123
	G		270	
Engineering	L	113	140	
	U	156	107	
	G	225	121	
English	L	40	40	97
	U	44	49	97
	G	141	91	
Mathematics	L	43	54	74
	U	63	65	74
	G	152	167	
Sociology	L	27	32	69
	U	33	37	69
	G	173	65	

COUNSELING SERVICES, CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

Reason	Per cent	Visits/ Student	Cost per Service
Academic Advisement	25	1.3	$38
Choice of Major or Career	25	2.8	$50
Personal Counseling	17	4.3	$79
Other (draft, marriage, and family)	3	3.3	$58
Combination of two or more	31	2.7	$49

Figure 9.9

ALLOCATION OF INDIRECT COST COMPONENTS

Type	Unit	State College	
		A	B
Counseling and Guidance	FTE Student	$28.14	$37.90
Physical Plant Operations	Assignable Square Feet	3.24	2.39
Library	Student Credit Unit	2 95	3.68

3.2. Cost Allocations and Distribution to Outcome Categories

The allocation of indirect costs to outcomes or activities is particularly difficult in higher education. Since the education process is complex, it is not immediately evident which resources relate to particular outcomes, and the situation is further complicated by institutional incentives. If an institution has training, research, or other grants and contracts which permit reimbursement of overhead expenditures, then a federal "indirect cost rate" must be determined, and there is an incentive to make as many of those allocation judgements as possible which maximize the government's contribution. These judgements are not necessarily the same that would be made if the institution were attempting to best represent the underlying economic process. Additionally, both efforts are hampered by lack of data; if only because the process is complex, its data representation must also be complex.

Some of the efforts to identify allocation procedures for management use were conducted by the California State University and Colleges, based first on their early implementation (1969-70) of the draft NCHEMS Program Classification Structure, and later using the NCHEMS the variables used as the basis for distribution of costs - were FTE students, FTE faculty, assignable square feet (ASF), and library classification of books.

Figure 9.10 shows two cost allocation techniques recently used in deriving average full unit costs for student credit units at California State University, Fullerton as part of the 1972 NCHEMS pilot implementation of their planning and management tools, and for California State University, Northridge, as part of a study of allocation sensitivity(2). The variations arise primarily from data availability - since CSU Northridge had assignable square feet by discipline and library utilization information. Some of the difference results from the institution's use of resources, for example the expenditures for computing were distributed differently because of emphasis in the respective business, engineering, and science programs. Both Young and Posin would have preferred to have had headcount students available to use for allocating student services and student activities expenditures, but that data was unavailable. Both used the NCHEMS Cost Finding Principles Software for the allocations rather than either of the projection models, since CEM and RRPM have only an elementary allocation capability, specifically limited by the parameters available to the model - FTE faculty (FTEF), FTE staff, student credit units (SCU), and faculty and staff salaries.

In order to determine the variation in average cost which would result from merely choosing a modified allocation method, Posin compared the results of different allocation parameters. The results of two alternative methods - FTE students and FTE faculty - for library expenditures is shown for some representative disciplines in Figure 9.11. Posin concluded that there was no significant difference in these two techniques, but Young, in his previous work, did identify significant differences between these two methods compared with the use of number of volumes by Library of Congress classifications to allocate library expenses.

3.3. Cost Per Student

A student does not take all of his work in a single discipline, and a "student major" commonly involves work in several different departments. There is, of course, some historical consistency arising

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1) For the first major effort, see Ref.15 for the description of the San Fernando Valley State College system.

2) The Fullerton pilot is described in Ref.9. The work on cost allocation procedures by Michael B. Posin for the California State University and Colleges is not yet published.

CALIFORNIA STATE COLLEGE
EXAMPLES OF COST ALLOCATION PARAMETERS

PCS Number	Type of Expenditure	NCHEMS Fullerton Pilot	CSU, Northridge (Posin Study)
		Dollars	
6.5	Physical Plant	SCU	ASF
6.1	Executive Management	FTEF	FTEF
6.4	Logistical Service	SCU	ASF
6.3	General Administration	SCU	FTES
6.2	Fiscal Operations	SCU Dollars	90% SCU 10% FTEF
6.7	Public Affairs	FTEF	90% FTEF 10% FTES
4.6	Academic Planning	FTEF	FTEF
4.4	Computer Center	36% SCU, Bus. 18% SCU, Engr 6% SCU, Physics & Chem. 30% SCU, All others	26.5% SCU, Bus. & Engr. 73.5% SCU, All
4.1	Library	FTEF	50% FTEF 5% FTES 45% SCU
4.3	Audio-Visual	FTEF	SCU
5.1	Student Activities	SCU	FTES
5.3	Counseling, Testing and Placement	SCU	FTES
5.4	Financial Aids	SCU	FTES
5.5	Student Support Services	(none)	FTES

from course requirements and options of a specific degree program. The "induced course load matrix" (ICLM) is used by the WICHE/NCHEMS models to relate expenditures to student majors(1). This procedure examines the mix of courses taken by the average student in a major program and attaches costs to each of the student credit units, as shown in Figure 9.12. Remembering that these computations represent many levels of students, instruction, majors, disciplines and departments, the computation becomes intractable without the use of computers. Fortunately, the NCHEMS resource models - CEM and RRPM - both perform these computations directly. Because a student major is typically a mix of high and low cost disciplines, the cost per student does not directly evidence the marked variation in costs of student credit units. Figure 9.13 shows some of the differences between an

---

1) This concept was developed by George Weathersby in 1967 and described in Ref.17.

Figure 9.11

COST SENSITIVITY, LIBRARY ALLOCATIONS
(AS CALCULATED IN THE POSIN STUDY FOR
CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

Discipline	Student Level	By FTE Student	By FTE Faculty	Per cent Change
Art	L	64.43	64.34	-0.1
	U	77.44	78.57	+1.5
	G	170.16	179.92	+5.7
Business	L	60.20	60.09	-0.2
	U	60.42	60.34	-0.1
	G	95.04	98.10	+3.2
Chemistry	L	80.17	80.46	+0.4
	U	105.04	107.32	+2.2
	G	311.00	329.99	+6.1
Engineering	L	101.27	101.58	+0.3
	U	131.64	134.29	+2.0
	G	181.64	188.11	+3.6
English	L	52.41	51.93	-0.9
	U	53.22	52.82	-0.8
	G	128.1	134.92	+4.8
Mathematics	L	49.40	48.98	-0.9
	U	65.59	66.83	+1.9
	G	104.49	109.74	+5.0
Sociology	L	38.03	36.38	-4.3
	U	48.31	47.69	-1.3
	G	137.65	146.01	+6.1

Key:

L = 1st & 2nd year.
U = 3rd & 4th year.
G = graduate.

FTE in a discipline - 15 annual student credit units - and a FTE student major. Resulting costs may be higher or lower, depending upon the mix of courses for a degree program and the relative cost for the individual discipline involved.

3.4. Cost Models and Cost Estimation

The NCHEMS cost models can, and have been used to develop instructional unit costs. Because they provide all of the details of the computations, yet provide well organized cost reports, the models have been well received by state level agencies and governing boards. However, they do contain some limitations resulting from their primary designation as future cost estimators. Good approximation of future costs can result from rather crude per FTE estimates of the indirect costs; model precision is obtained only for the

COSTS FOR AN UPPER DIVISION CHEMISTRY MAJOR

Department	Number of Units(1)	Cost/Unit(2)	Cost
Art	0.11	23	3.08
Biological Science	3.05	39	118.95
Chemistry	10.70	78	83.46
.			
.			
Foreign Language	2.70	27	72.90
.			
.			
Mathematics	3.30	37	122.10
.			
.			
Physics	2.35	53	124.55
Political Science	0.33	24	7.92
Psychology	0.36	23	19.78
Religious Studies	0.05	19	.95
Total	30.0	52	1,546.25

1) Semester credit hour.

2) Approximate averages for different levels of instruction.

Figure 9.13

AVERAGE COSTS FOR MAJOR AND DISCIPLINE INSTRUCTION

	FTE Student (15 SCU)	STE Student Major
Art	$ 771	$ 881
Business	682	770
Chemistry	1,085	1,592
Engineering	1,727	1,557
English	724	847
Mathematics	870	1,060
Sociology	555	702

instruction program, where approximately half of the expenditures normally occur. For purposes of mid-range planning (one to five years), it may be preferable to omit indirect costs. This permits the cost estimation models to be used for program considerations - degree programs, departmental organization, enrollment policies - rather than attempt to identify future cost allocations.

There are, however, some operational limitations to the NCHEMS cost models. Significantly, they do not consider the effects of tenure. As long as all departments of an institution were expanding, tenure enrollments beginning to decline, tenure may result in increased costs when workload declines below average, and normally required faculty staffing adjustment cannot be made. Similarly, the cost models do not adequately consider institutional investment decisions. Typical investments include program or course development, which may be substantial with a new department and associated degree programs; new projects such as library automation, which will change both current and future operating costs; and remedial or supplementary instruction which commonly occurs in the student services program.

As an example of the use of a cost model to evaluate program alternatives based on cost data, California State University, Northridge considered several current possibilities. One was to reduce the number of hours taken in undergraduate major subject areas. The Art Department was expected to reduce the number of hours in its major by either three or six (one or two required courses). Using the Cost Estimation Model, it was suggested that the Art Department faculty should be reduced from 77 to 75 or 74, the number of lecture and laboratory sections from 149 to 145 or 141, and the resultant annual cost per upper division major from $1,171 to $1,154 or $1,137(1). This was to be accomplished by changing the induced course load matrix to represent the new requirements, and re-running the model. In this case the Art Department recognized that there would be little change in the departmental staffing and offerings. The model did identify, however, that one additional faculty member would be required in the Anthropology Department, to teach the five additional lecture sections which were needed.

Many other institutions - including Azusa-Pacific College, Kearney State College, SUNY Plattsburg, and the University of Illinois - are now using cost models in their planning program to evaluate the complex interaction of what have historically (and deceptively) been viewed as apparently straightforward academic decisions.

4. ISSUES IN COSTING

4.1. Applicability of Cost Analysis

Several years ago, educators were predicting rapidly changing methods of instruction, types of students, attendance patterns, and program articulation. Terms like "university without walls", "self-paced learning", "educational television", and "open-admissions" were often heard. Traditional cost models were declared obsolete by

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1) Data taken from Ref.4, pages 16-18.

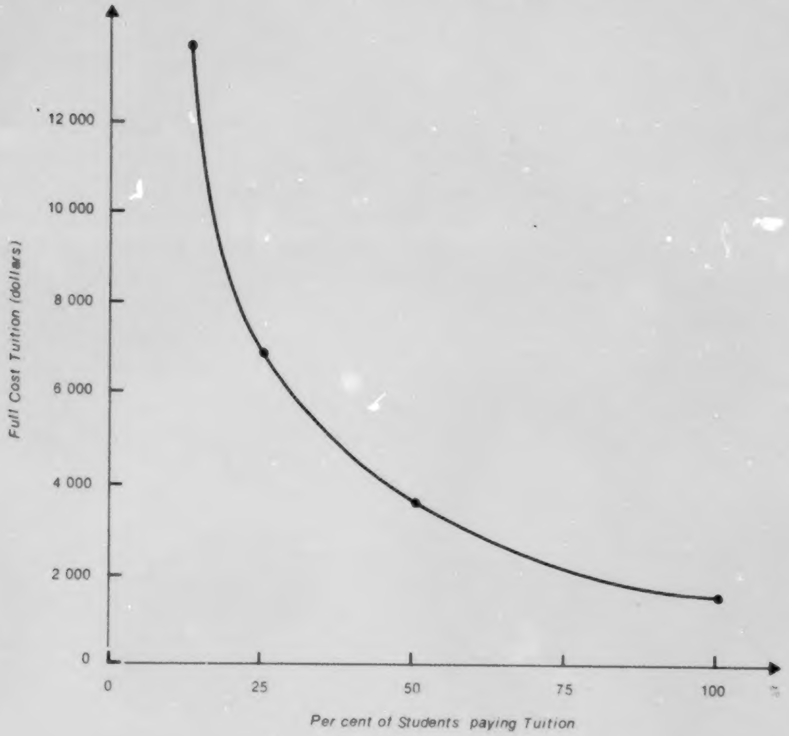
far these have not occurred at the rate or magnitude predicted. Rather slow changes in institutions, programs and student bodies are occurring. While it is clear that current cost models will not be valid in the long run, they do appear applicable for mid-range planning. As changes are well identified and attempted by some institutions, then new cost models will have to be built better representing new models of operation. Validity of cost analysis is not a general issue. Rather, cost analysis must be related to the specific educational process which is being considered. Only recently has cost analysis been used to evaluate external degree programs, the use of educational television, and credit by examination. The discipline of cost analysis is beginning to make this planning more specific, and hopefully resulting in educational improvement.

4.2. Transfer Payments

Many institutions have attempted to incorporate student financial aid into the cost models. However, student aid is better considered as a transfer payment; in the sense that those other than enrolled students contribute to student aid funds, student aid merely shifts the costs to other sources of income; it does not change institutional costs.

Student aid may be a cost redistribution mechanism, particularly since some institutions are now using part of student tuition to offset student aid. Although this redistributes the costs from those students who cannot pay to those who can, there is a practical limit to such a social reallocation. Figure 9.14 shows the relationship between a theoretical full-cost tuition for California State University, Fullerton, and the per cent of students who could then contribute. If only one-half of the students pay, then the tuition would be $3,422 instead of the average cost of $1,711; if only one-fourth could pay, then the tuition would be $6,844. Clearly there is a practical limit to tuition - because of the competition of public institutions not charging at full cost - and, hence a limit to the number of students receiving financial aid from intra-institutional transfers.

Because of these considerations, student financial aid is not considered in most cost analyses or cost models. The issue is one of cost rather than of pricing. This is not to ignore the costs of student financial aid in the sense that a source of income must be identified, but rather to recognize it as an income limitation, not an expenditure problem. There is, of course, an identifiable cost of administering student financial aids, particularly student loans, which is typically included as an administrative expenditure of the institution.


COST-TUITION RATE RELATIONSHIP

Cost analysis is beginning to identify another problem of cost distribution. As the cost data indicates, using single-rate tuition for students in the social sciences forces them to subsidize students in engineering and natural science. One of the issues which may arise from current unit costing efforts relates to differential tuitions in lieu of a single-rate. Since this would give one major a higher tuition rate than another, the fundamental principle of free choice of major by the undergraduate student may be violated. On the other hand, as tuition in private institutions and non-resident tuition for public institutions increase beyond the costs of the low cost programs, subsidy is occurring. Students may not long accept this policy as equitable.

4.5. Investment and Depreciation

Most cost studies have omitted consideration of capital expenditures for building and equipment. In higher education, many buildings guaranteed loans. Such capital use is in large part furnished by the federal government and therefore not eligible for federal reimbursement of indirect costs.

But there are two significant reasons for including the costs of capital expense. First, present costs are understated because of building use and equipment consumption which exceed current replacement. One study at California State University, Northridge, indicated that about 35 per cent of the capital budget was spent for equipment, with an average depreciable life of 5.8 years. When the campus building program decreased abruptly, the college then began to "use" equipment faster than equipment replacement was supported by the current budget, resulting in a consumption of capital. These uses must be identified in order to preclude a future "obsolescence crisis". Secondly, instruction and research is becoming more equipment intensive. It would be inappropriate to exclude the cost of computers in computer-aided instruction, cyclotrons in physics research, or the use of audio-visual equipment. If such capital costs are not included, the costs of these alternatives are understated, and the institution may be assuming a future capital replacement burden without understanding the magnitude of these "deferred" costs.

Depreciation accounting appears requisite to any valid cost accounting or cost analysis(1). While it will be difficult to begin, the improved control of building and equipment use and maintenance, and replacement, may make accounting for capital items worthwhile. If an institution has such inventory controls, then depreciation accounting is relatively inexpensive. It does present some conceptual problems in establishing an appropriate cost basis, but this is a secondary problem.

So far, virtually all investments in course materials have been made by faculty members. As institutions begin to use high investment media like television and computer-aided instructional programs, some of these costs must be borne by the institution, either as development costs or product royalties. These investment costs must be identified in order to make accurate assessment of both the impact on the institution and decision alternatives in the future. This area of costs is relatively new, and procedures remain essentially undeveloped.

4.4. Risk Analysis

Most institutions of higher education have not yet faced an uncertain future. Tenure has not been a cost issue with constantly

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1) Cost analysis differs from depreciation accounting by its identification of equipment replacement by time and amount; since capital is replaced as needed, the cost is included.

abrupt shifts from one discipline area to another, and there has not been open competition for students. With declining enrollments, new interests in education, and lack of general support for research, the future is indeed uncertain; linear projections of growth are no longer satisfactory. Cost analysis should now consider a number of alternative futures to identify the sensitivities of cost estimates to such factors as enrollment levels, types of instruction, type of students, and research demand.

Some have viewed insurance as a solution to the problem risk. However, an institution cannot insure against the most serious long-run uncertainties. There is no insurance for changes in enrollment, shifts in federal and state policy, modifications of student preferences, or obsolescence of institutional methodology. In a world of change, the uncertainties of the external forces may be the greatest risk for the institution.

Cost estimation models can be useful in determining how these factors can impact institutional costs and operation. Several enrollment levels - low, average, and high - should be considered; alternative funding levels and patterns for research must be studied; and for long range projections, the impact of instructional technology should be carefully analyzed. This can only be done by a conscious and careful identification of the uncertainties, and sincere attempts to measure their potential impacts.

5. THE FUTURE OF COST ANALYSIS IN HIGHER EDUCATION

5.1. The Need and Capability

As institutions have faced increasingly limited resources, cost analysis has become a tool used by educational management to identify the resource impacts of decisions. This has been particularly necessary, if only because most decisions in higher education have long term effects and induce costs in other parts of the social organization. At the same time, the issue of public accountability has created a need for detailed cost data. The needs, however, can be quite different, as shown here.

Our capacities for cost analysis are increasing. Only now is the research in education beginning to produce costing tools which are complex enough to be valid, yet simple enough to be usable. Developments like the NCHEMS models and Cost Finding Principles software, and the installation of program cost accounting systems are beginning to make detailed data available for institutional cost analysis.

At the same time, management techniques which employ the results of cost analysis are becoming a part of the higher education curricula management are electing careers in higher education. Substantive training has become accepted as necessary for the current institutional staff.

This confluence of need and capability is beginning to improve the management of institutions of higher learning and their credibility as a well managed and vital part of American society. It may also cause institutions to explore new alternatives, and become an incentive to creative new and innovative ideas.

6. SUMMARY

As institutions of higher education, their governing boards, and supporting agencies require more cost information, the techniques of cost analysis are being increasingly used. In some institutions, situations are sufficiently developed that cost analysis is being used as part of the planning process. This paper has provided background information and definitions, and has described some of the techniques currently employed for determining average, marginal and full unit costs, and for identifying cost components. It also suggests ways in which current resource and cost models can be used as costing tools, in addition to how they might be used for the estimation of future resource requirements and evaluation of educational alternatives.

Several issues of costing in higher education are identified: applicability, modeling process, transfer payments, investments, and risk analysis. This paper suggests that cost analysis and improved costing capability will make economic analysis a more valuable tool for institutional management, and may well lead to new policy alternatives for institutions of higher education.

* * *

Many of the examples in this paper were taken from the earlier work of Michael E. Young, the yet unpublished work of John Ryan and Michael B. Posin of the California State University and Colleges, the efforts of Dr. Gary Olson, Kearney State College (Nebraska), the contributions of Dr. Patricia Rueckel, Georgetown University, and the results from a number of those institutions which have used the NCHEMS Resource Requirements Prediction Model and made their data reports public. Much of the descriptive material comes from a research project sponsored by the Interim Study Committee on Higher Education of the Nebraska Legislature, as directed by Winn Sanderson, Legislative Analyst.

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PART THREE

INTRODUCTION

Part Three discusses implementation of planning models. This section's first chapter (Chapter 10) is an overview of the process of implementation. The chapter identifies and describes the four main phases of implementation: data generation, model validation, organizational changes and training. Some parts of these phases are discussed in greater detail in succeeding chapters because of their importance and complexity. These are: data integration of existing files (Chapter 11), structural changes necessary for model implementation (Chapter 12), and simulation models used for training (Chapter 13). In order to play the game models USG and RRPM discussed in Chapter 13 it is necessary to have instruction manuals. These manuals appear in the Appendices II and III at the back of the book.

Chapter 10

IMPLEMENTATION OF PLANNING MODELS(I)

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1) This chapter is based on the author's experience of implementing RRPM 1.3 and is reported in Hussain (1971) and Hussain and Freytag (1973).

1. INTRODUCTION

There are at least two definitions of the term "implementation". One definition considers implementation to start after the model has been conceptually developed and programmed (if a computer is needed). In this definition, implementation includes the phases of getting the solution to work on local resources (equipment and personnel); collecting the data necessary for the model; validating the models; and finally, educating personnel to use the model. In the second definition, implementation covers the phases of education on the model and acceptance of the model by the user. For the purpose of this paper we shall adopt the first definition. It does subsume the second definition.

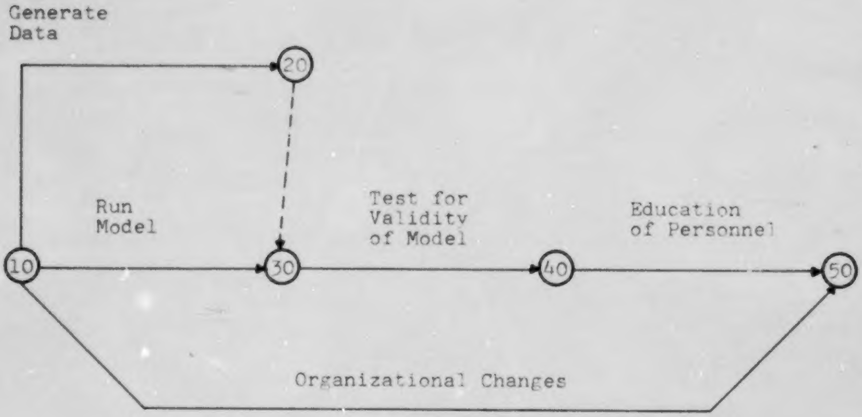
The process of implementation is shown in Figure 10.1. In it, each activity (or task) is represented by an arrow, and the precedence of the arrows represents the necessary sequence in which the activities must be performed. It is a formalized representation of the implementation of a complex model. In a simpler model some activities may be absent or combined; but conceptually the representation is generic and valid for most planning model implementations.

The main activities of implementation as shown in Figure 10.1 will be discussed in this chapter and in the following order: generation of data (activity 10-20); running the model (20-30); testing for validity of model (30-40); the education of personnel (40-50); and finally, organizational changes (10-50).

2. DATA GENERATION

Data required for planning models can be classified into two groups: one is the data that can be extracted from the existing institutional data base; and two, data that must be generated specifically for the models. The former requires considerable integration of the data base and special linking elements. This is a complex subject and needs a separate chapter - Chapter 11. The second type of data - data required specifically for the planning models - will be discussed in this chapter. Also to be discussed are the related problems of stability of the data and its pre-processing for validity and completeness.

OVERVIEW OF THE IMPLEMENTATION PROCESS



2.1. Special data needs for planning models

The special data needed for planning models (in addition to planning parameters determined by the decision-maker for each simulation run) are mainly of three types: estimation coefficients, financial data and the Induced Course Load Matrix (ICLM). The first set, the estimation coefficient(1) can be determined by someone with statistical experience and a relevant statistical computer program(2). The financial data is required as dependent variables in the estimation equations of a resource and cost model. It is difficult if the model uses a "program" approach since the accounting systems of most institutions are not by programs. This requires considerable processing for disaggregation and regrouping of data. In some countries, like Germany, it is very difficult because the data in the budget is by aggregated categories such as personnel without classifications of academic versus support personnel, much less by rank and programs.

The ICLM raises problems of stability to be discussed later, but even without this problem the generation of the ICLM is often a serious problem. This is largely because of its four dimensions(3)

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1) These are the a's and b's in the estimation equation of the type $Y = a + bx$ where x is the dependent variable.

2) For a critique of computerized statistical programs, see Longley (1967).

3) As defined in RRPM, HIS and CAMPUS the ICLM is of the following form: I.C.L.M. (m, s, i, j) where
m = major of student (field of study)
s = student level
i = discipline offering course
j = level of course offered
(This is implied in the activity approach of HIS and CAMPUS).

required by most models of resource and cost. Much of this data would be found in files needed for record keeping purposes and could be extended with little marginal cost if this need were anticipated at the time of designing files for record keeping. This problem illustrates one of many reasons why record keeping and planning needs must both be kept in mind while designing institutional data files.

The generation of additional data required for planning models is not a trivial matter. It is often the deciding factor in selecting between an aggregate model such as RRPM and CAMPUS VII or a detailed model such as CAMPUS VIII, MSAP or TUSS. Also, it sometimes will make the difference between a more sophisticated version or a simple version of a model. This happened with HIS/A which had an optimizing module for faculty assignment. This module was dropped in the later version B of the HIS model, all because of the lack of detailed data needed.

2.2. Stability of data

Some of the data input required by planning models is semi-processed data such as the Induced Course Load Matrix (ICLM) (where each column represents the load on different courses or departments by an academic program). ICLMs based on historical data are used to describe future student enrollments. But for a historical ICLM or a set of ICLMs to represent the future requires considerable processing to allow for changes over time caused by changing curricula, changing student preferences, changing academic requirements, and incorrect reporting of majors(1).

Several investigators have suggested that an ICLM based upon data from more than one semester (or quarter) may provide more accurate forecasts than an ICLM based upon a single semester's data. Toward this end, the following schemes for defining the coefficients ICLM have been suggested:

1. A simple average of coefficients from several past periods.
2. An arbitrary weighted average of past coefficients with the last period having the largest weight.
3. An arbitrary weighted average of past coefficients with the similar period coefficients (e.g. Fall if Fall is the forecast period) having the largest weight.
4. A weighted average where the weights are student enrollments in the particular major and level.
5. Moving averages of past coefficients.

---

1) For a sampling of the literature on the subject, the reader may consult the following resources: Breneman (1969); Jewett et. al., (1970); Lawson and Emanuel (1970); and Enscore et al. (1970).

6. Forecast of the coefficient from alinear (or non-linear) regression of the past coefficients on a trend variable.
7. Definition of the coefficients as student-contact-hours rather than student credit-hours.

Another line of investigation that may prove useful is concerned with the development of the statistical properties of the ICLM coefficients based upon the sample values provided by past data. Such a development would lead to interval rather than point estimates of the forecast variables. In any event, more investigation is needed on the definition of ICLM used for forecasting faced with its unique causes of instability.

The problem of instability arises also in transition matrixes used in Student Flow Models. Again this is a problem worthy of more work, both theoretical and empirical.

2.3. Pre-processing of data

An important phase in generating data for planning models is that the data must be pre-processed, that is, processed before it is used for its main processing function of calculations in the model. This pre-processing should validate the input data (distinct from validation of output and model to be discussed later).

Validation of input data typically checks for alphabetic (or alpha) characters in numeric data fields (or numeric data in alpha fields) and the values of data within a given range. But the validations do not detect, say, an incorrect alpha character in a valid alpha field; or an incorrect numerical value within a legal (allocated) range (such as an incorrectly aged man at 75 years old because this value is possible even though highly unlikely). There is no guarantee against such errors but they can be reduced by printing all the input and listing them in formatted reports so that they are easily read, understood and analysed. Then the user can often detect errors. This happened frequently in the pilot testing of RRPM(1). Furthermore, this part of the Pre-Processor had two unexpected side-benefits.

One, it involved the user and gave him confidence in his input which no longer took the form of spots on a magnetic tape, that he could neither touch nor comprehend, but instead was listed in reports that were designed to facilitate checking. The second by-product was that these reports had considerable analytical value. It identified relationship otherwise hidden in a mass of numbers. It better exploited the large amount of data collected by planning models for analytical purposes. Thus, all administrators should insist on such pre-processing and further insist that the pre-processor be designed so as to facilitate its use.

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1) For a detailed discussion see Hussain (1971), section 5.3.

Most planning models of resource allocation have a pre-processor, especially CAMPUS and RRPM. RRPM 1-3 had an elaborate pre-processor with three parts as follows:

PPP1: Reference Reports and diagnostics of errors.
PPP2: Reports for checking and analysis.
PPP3: Modification of data.

The flow of data using the RRPM 1-3 pre-processor is shown in Figure 10.2. The important point to note is that both the administrator (manager) and the analyst have important roles in the pre-processing process.

3. RUNNING THE MODEL

In parallel to collecting the data, one must run the model (activity 20-30 in Figure 10.1). In many cases this involves running a computer program on local equipment. If the program is well tested and documented and if the local equipment is like that on which the program was tested then this could take 48 hours lapse time, as was the case of one implementation of RRPM. Often, however, this is not the case. Sometimes the local computer is different, or it may be the same and have a different operating system, or it may have less memory than what is required. Sometimes, the model has to be modified to meet local needs. This process can be time-consuming, especially if the model being implemented is a new version. In one such case (of model changes, new version and a different computer) with the implementation of CAMPUS VIII, it took nearly a year lapse time and 1½ man-years of a highly skilled programmer. If the model design is not firmly "frozen" then this process could last "indefinitely".

4. VALIDATING THE MODEL

4.1. The validation process

Validation is the process of verifying that the model performs according to its design specifications and with the institutional data (shown as activity 30-40 in Figure 10.1). Validation is typically performed by the developers but errors could arise either because of incorrect input or misinterpretations and misunderstandings by implementer and user. Also, the model is often modified by an institution to meet its unique needs and hence needs to be validated.

There are many approaches to the validation of models(1). The most commonly used approach is to pretend one is in the past, predict

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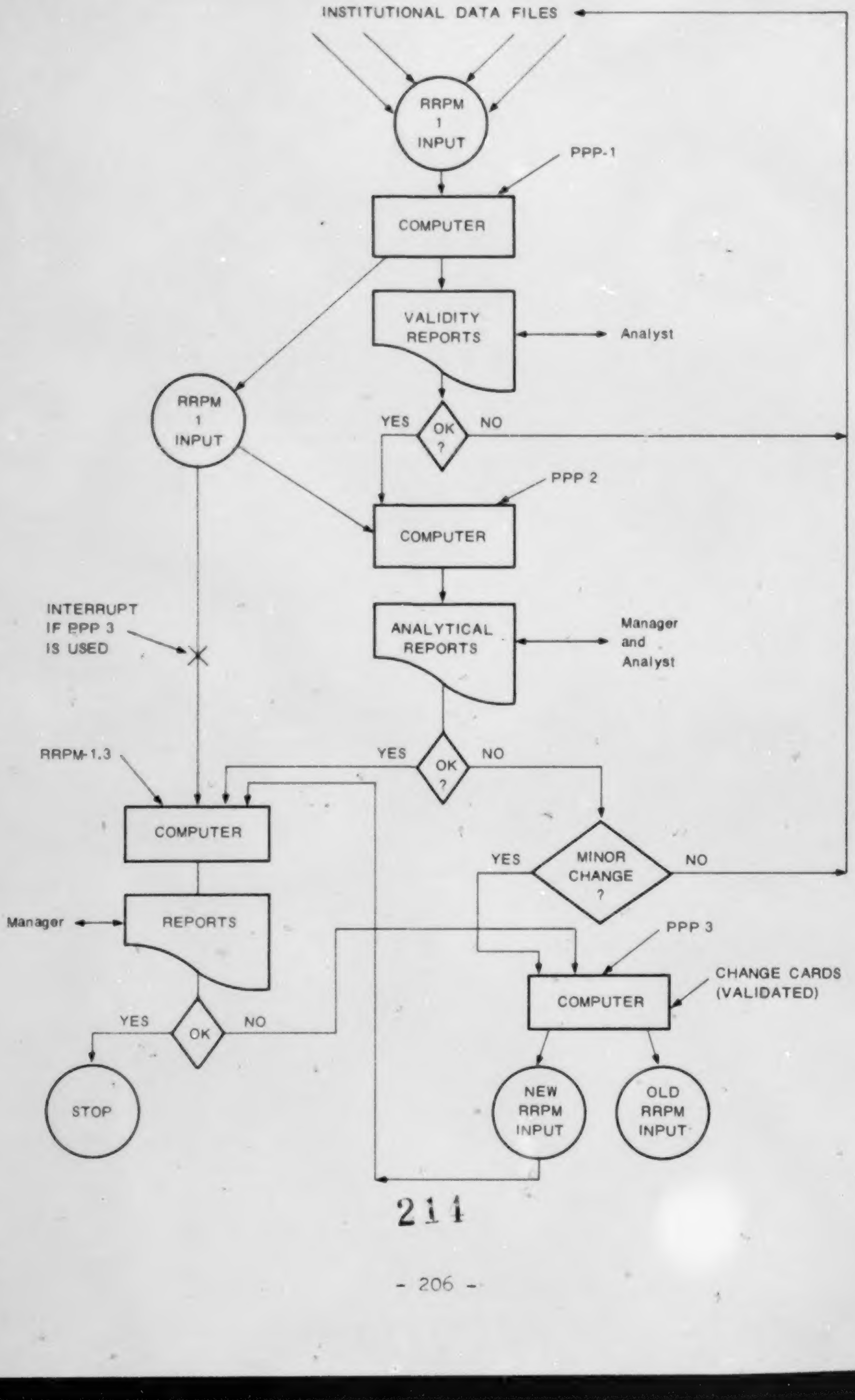
1) See Naylor, et al., (1966), pp.311-14. The authors discuss Synthetic Apriorism, Ultraempericism, Positive Economics and Multistate Verification. For a discussion of historical verification see pp.316-317.

USE OF PRE-PROCESSOR


INSTITUTIONAL DATA FILES
RRPM 1 INPUT
PPP-1
COMPUTER
VALIDITY REPORTS
Analyst
YES
OK ?
NO
RRPM 1 INPUT
PPP 2
COMPUTER
ANALYTICAL REPORTS
Manager and Analyst
INTERRUPT IF PPP 3 IS USED
RRPM-1.3
YES
OK ?
NO
COMPUTER
YES
MINOR CHANGE ?
NO
Manager
REPORTS
PPP 3
CHANGE CARDS (VALIDATED)
COMPUTER
YES
OK
NO
STOP
NEW RRPM INPUT
OLD RRPM INPUT

reality. Typically, the comparisons at first will not be satisfactory but after changes are made to improve the predicted results, another comparison is then made. This cyclic procedure is depicted in Figure 10.3.

The recycling may result in changes in one or more inputs. This is shown in Figure 10.4 where three different iterations are shown. In the first case, evaluation 1, the input data to the model was found to be incorrect (e.g., costs were coded to the wrong program) and had to be corrected. Nothing else changed. In evaluation 2 the model was found to be incorrect and this required not only changing the input data required but also the accounting data needed for comparison. This happens often with the cost relationship that needs to be modified. Such a change is one of "form" rather than a change in data, which is a change in "content". A structural change of the "form" of the model typically requires changes in the data "content" - both data to run the model and data from the accounting system needed for comparison and evaluation.

As stated earlier, a structural change may require changes in accounting data needed for validation. This may pose a serious set of problems. One problem is that the categories in the accounting data may not correspond to the program classifications used in the model, especially if the institutional Chart of Accounts has changed in the period being tested. The second possible problem is that the accounting data are by fiscal year and the annual data for the model are by academic year. A conversion of one to the other is necessary.

The accounting data used for evaluating predicted results could be either historical, current, or both historical and current. The criticism of the historical data alone is that they may not represent the current or future state of operations; the objections to current data alone may be that they represent only a small sample and may not represent trends in an institution. Hence, the combination of historical and current data is typically the best solution.

The number of iterations for each type of problem will depend on the degree to which the model was tested, the uniqueness and seriousness of unique local problems, the state of the data base, and the experience of the implementers. In one pilot implementation of RRPM 1.3, the values in iterations as shown in Figure 10.4 were as follows: k = 23, l = 5, m = 24, and n = 9.

4.2. Considerations of experimental design

The selection and comparison of historical data as a strategy of validation raises questions in experimental design. At what level of aggregation should the results be compared for validity? What

Figure 10.3

PROCESS OF VALIDATION

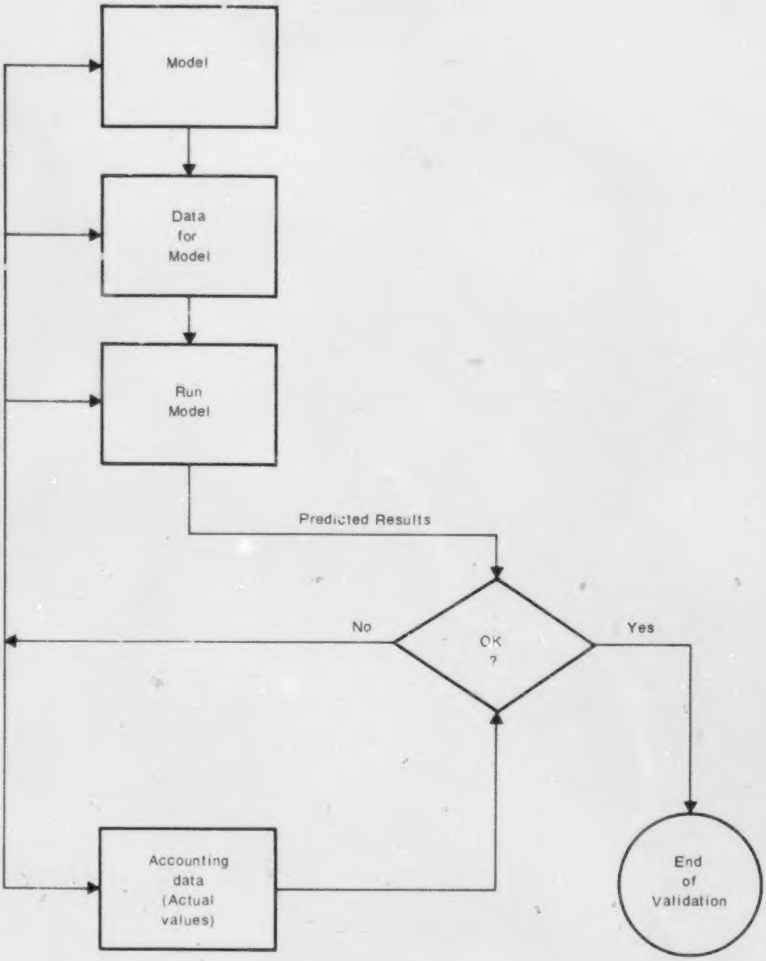
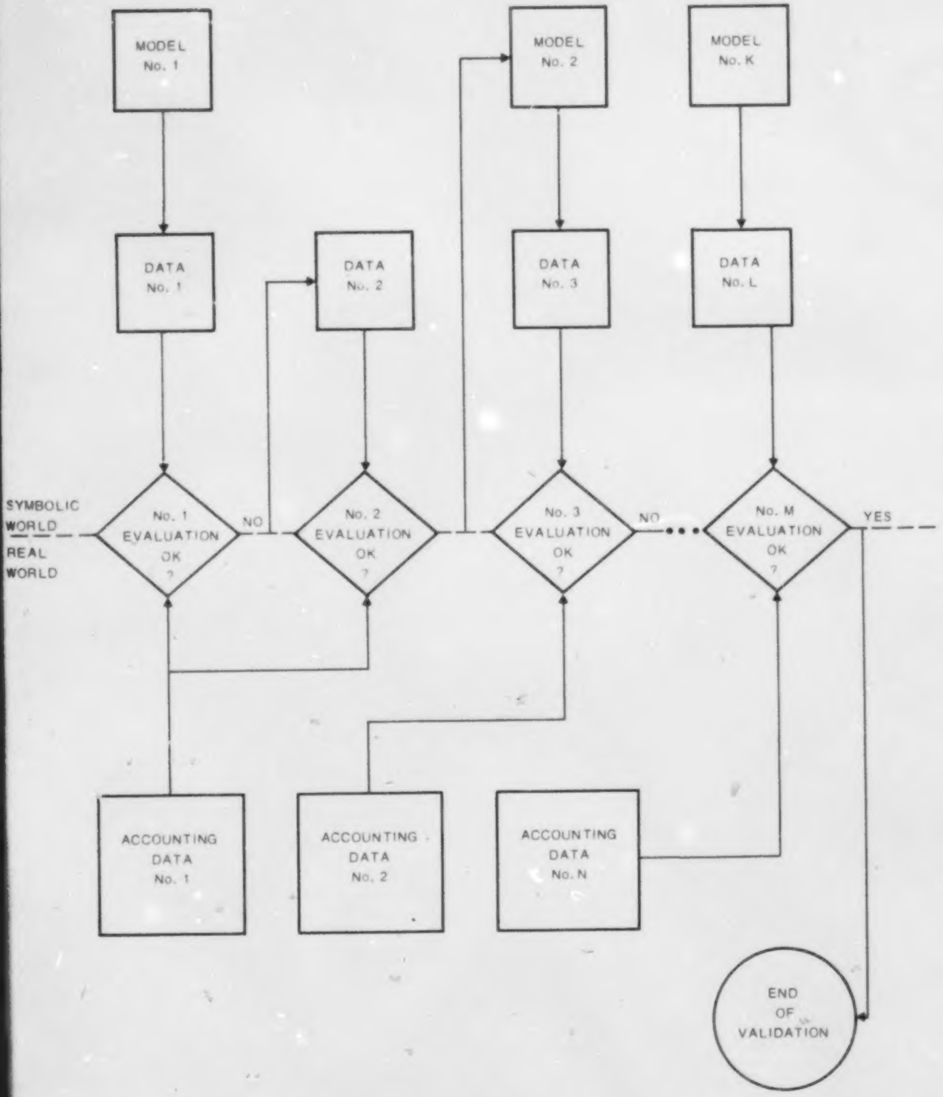

Model
Data for Model
Run Model
Predicted Results
No
OK ?
Yes
Accounting data (Actual values)
End of Validation

Figure 10.4

ITERATIONS IN VALIDATION


MODEL No. 1
MODEL No. 2
MODEL No. K
DATA No. 1
DATA No. 2
DATA No. 3
DATA No. L
SYMBOLIC WORLD
REAL WORLD
No. 1 EVALUATION OK ?
NO
No. 2 EVALUATION OK ?
No. 3 EVALUATION OK ?
NO
No. M EVALUATION OK ?
YES
ACCOUNTING DATA No. 1
ACCOUNTING DATA No. 2
ACCOUNTING DATA No. N
END OF VALIDATION

be tested? What levels of divergency between predicted and actual expenses should be allowed? Each of the above questions should be answered with great care.

4.2.1. Levels of aggregation for testing

The answer to this problem can be implied by the following case study. One pilot institution found that its predicted annual budget was within ± 5 per cent of the actual value. Closer analysis, however, showed over a 100 per cent variation in two departmental budgets. These were in opposite directions and hence did not greatly affect the overall value. But the moral is clear: one must test at the level of aggregation at which resources are allocated and spent. This may be the departmental, division, or college level.

4.2.2. Sample size

Should a sample of administrative units be taken for testing, and if so, what should be the size of the sample? The answer is again implied by the case above. Two compensating errors can go undetected; hence, the predicted budget of every administrative unit receiving and spending resources must be tested against the actual value.

Thus far, the discussion was confined to the validating of a model for an institution. If the validation is for a model that will be used throughout a country, then the sample should be stratified by judgement. This was the case when 8 institutions were selected for pilot testing RRPM 1-2(1). The institutions were selected such that they represented all types of institutional funding (private and public institutions); all levels and types of institutions (Junior Colleges as well as doctoral institutions); all sizes (sizes ranging from 100-25,000 students); and different types of campus organisations (single as well as multi-campus institutions). The sample, however, was not typical in that the selected institutions had an above average level of motivation and analytical capability. This advantage, however, was compensated by the fact that, as pilot institutions they had more problems than an average institution using a pilot tested product.

4.2.3. Quantity of data

Sometimes there is little choice. An institution may have only three years of data (accounting data or data to run the model or both).

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1) For further details, see Gulko and Hussain (1971). For implementation reports by each of the pilot institutions, see Hussain and Martin (1971).

These data would suffice if the validation results were "reasonably" close. Anything less would be a point estimate and not very conclusive. It may be sufficient or it may satisfy one set of conditions but not necessarily another likely set of conditions.

What if there were data for 15 years? Should the model be tested for 15 years? Not necessarily so, because after a point, diminishing returns set in, and the cost of testing is not worth the information generated. This also may be true of much less than 15 years because past conditions may have been so different that they may no longer be applicable. Or maybe we do not want the model to be valid for the past because we do not want the model to duplicate the past. These are important considerations that must be examined before determining the quantity of historical data to be used for testing.

4.3. Standards of validation

In comparing the deviations between predicted and actual values one may well ask what deviation is allowed and acceptable and what is not. The allowance will depend on the importance of the variable deviating, the personality of the decision-maker and the experience with the model.

The comparisons between actual and predicted values can be made by a computer program or by tabulation. The first method is expensive, the second is difficult to read and analyze. Another approach is to use a Quality Control Chart with Upper and Lower Control Limits identifying the maximum positive or negative variations allowed. Points representing percentage variations are then plotted on the charts with points out of control quickly and graphically identified.

One such chart is shown in Figure 10.5. It shows actual deviations for a pilot implementation of RRPM 1.2. In it, the management had stated ± 10 per cent as the allowable tolerance for deviations. There is one point that seems "out of control" for 1969-70 - that is for program 5.4: Financial Aids. An inquiry of the Financial Aids officer indicated this point to have been caused by a totally unexpected sudden source of funds, a condition that could not have been predicted by RRPM-1 or indeed any model. The point being outside the control limits was therefore considered not "significant" and "satisfactorily explained".

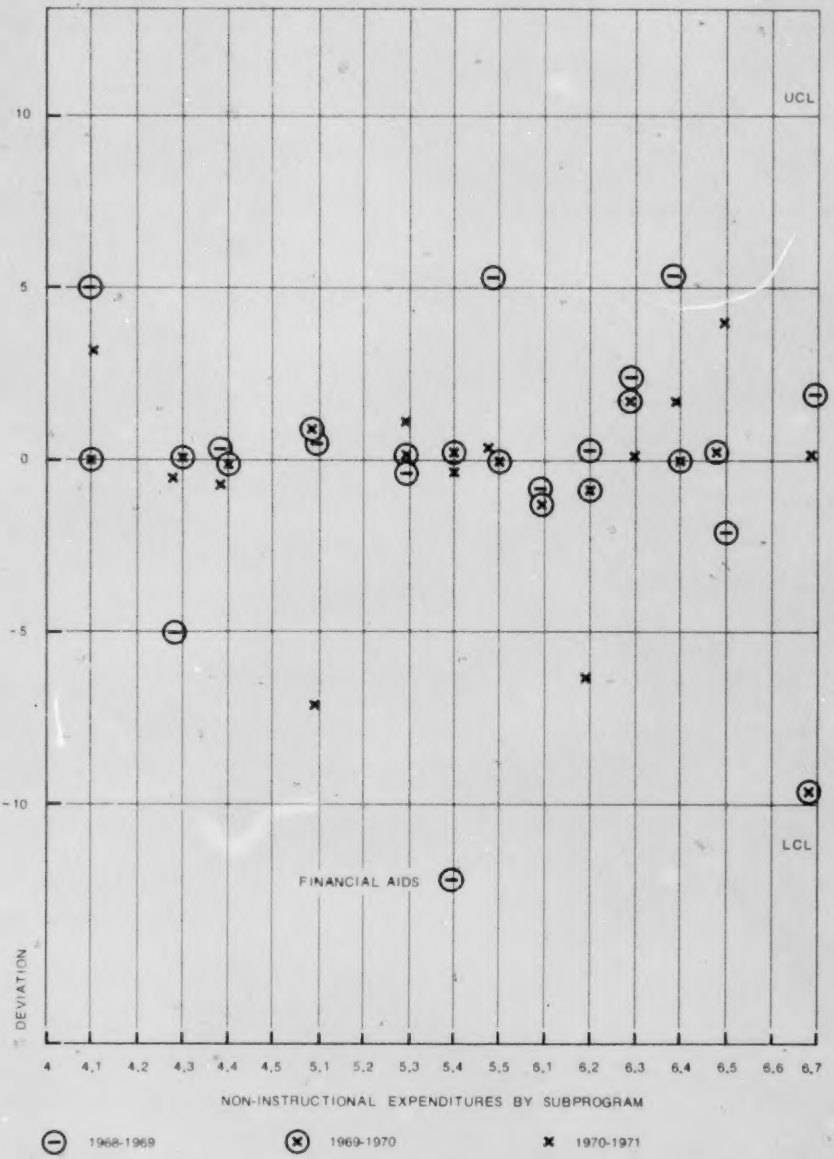
Another point almost "out of control" was for program 6.7. This was a small department where a fairly small absolute change in its result produced a relatively large percentage change. This deviation too was "explained" away satisfactorily.

4.4. Phases of validation

In a model like RRPM or CAMPUS that has many variables, including some whose values have to be predicted, it is desirable to do the

Figure 10.5

COMPARISON OF PREDICTED AND ACTUAL VALUES
(NON-INSTRUCTIONAL PROGRAMS)



values and progressively add more and more variables with uncertain values. This helps to isolate the problems and often makes the testing process consume less computer time and less effort.

Some phases of testing are suggested in Figure 10.6. The first stage selects a base year and uses all known data for that year. If the model tests out satisfactorily, then one does the same for all years to be tested. If that phase is also satisfactorily accomplished, then one pretends to be in the year previous to the base year in order to predict the base year. Herein appear the uncertainties of student enrollment, inflation factors, and the ICLM. They may be introduced collectively or, better still, separated by adding variables progressively. The ultimate stage would be to pretend that one were predicting five years (or as many years for which this is feasible and desirable), run the model for five years, and then compare the results with the appropriate years of historical data.

Figure 10.6

STAGES FOR VALIDATION

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1. Predict base year from known data for base year.
2. Predict other years with data for these years.
3. Predict 1.) using data for $\text{year}_{\text{base}} - 1$
4. Repeat 3.) for all years of testing period.
5. Predict for up to X years of data from year
   latest predicted, year -X

Another set of reports also used in RRPM is the TRACER that traces every input and calculation for any one academic program. This facilitates the "tracing" of an error in the input or in the computation.

4.5. Usefulness of model

Once all the errors in the model are removed to within acceptable tolerance, the model is then considered valid. But the model may or may not be useful. A judgement on the usefulness of the model should of course be made before the decision is made to implement. But it should be made repeatedly, especially during the validation process. One should ask the question: Does the model have the characteristics of a useful planning model? Then, of course, the characteristics of usefulness must be defined. Tom Mason (1973:2) has suggested the following criterion:

tion against what is known about the system it is supposed to represent.

2. It must be relevant. If the elements in the model that are selected to represent reality do not bear on the decision problem faced by the user, the outputs produced by the model obviously will have little use. The model-builder will find he has produced what Paul Jedamus has described as "an irrigation system for a mirage".

3. It must be flexible. If a model is to maintain its usefulness over time, it must be capable of being easily redefined or restructured to fit changing requirements of the user in a fickle world of changing issues. The thousands of dollars that may be invested in the design of a sophisticated analytical model are hardly worth it if the model can represent only a transient crisis. Another form of flexibility can be achieved by the use of very simple "mini-models" that intentionally deal with a narrow problem (such as the aging of tenured faculty). Large-scale system models must be written in generalized structural forms capable of frequent adaption.

4. Its content must be communicable. If the user cannot participate directly in the manipulation of the model, at least through an effective interpreter, he is less likely to (1) believe it, (2) see its relevance to his problems, or (3) participate in its adaption to his changing needs. If input, processing, and outputs of the model are the sole possession of a computer systems man, to whom the model is an end in itself, the non-technical user will quickly lose interest in its potential utility.

4.6. Detecting Problems

Detecting deviations in the model and their causes are similar to problems familiar to any analyst of an applications computer program. The analyst uses control totals as well as compares key calculations made on data from different sources. In addition, however, there are two sets of reports that help the validation process. One set of output identifies intermediate results with listings in different orderings. This helps to detect an error. For example, suppose that the budget for the department of Physics was incorrect, one would look in the list of salaries for Physics; if that were also incorrect one would then search for the number of faculty in the list of faculty for Physics; and so on till the error is traced. This capability exists in the RRPM model 1.3. Sometimes this does not help. If the input values look reasonable to the analyst, the problem may be caused by an exceptional situation about which the analyst is unaware. The person who could help here would be the department chairman of the discipline in question (i.e., physics in him find the error, we need to "trace" the computations of the physics discipline. This is one of the functions of the TRACER-TRAINER(1). It can trace the output for any desired discipline or department. It is the second set of output helpful in detecting problems.

4.7. Decisions regarding Validation

In decising the usefulness of the model and its validity, many questions must be answered. Some such questions are: What is the tolerance level of deviations? What deviations are "explainable"? What experimental design for validation is the best for the institution and the model? Is the model believable, reliable, flexible and communicable?

There are no mathematical formulae for answering the above questions. The answers to them are subjective and judgemental. But who should make these judgements? The technical analyst? The user? Or both? In many model implementations, the last approach has been used most successfully. The model is validated and evaluated by a team of technical analysts and users. Experience with the pilot implementation of RRPM 1.2 has shown these teams to be very helpful in suggesting future modifications to the model resulting in a model that is more relevant and believable and hence more useful. The team also proved an excellent means for involving users as well as for improving the understanding between the technical analysts and the users. It is in such collective efforts that the "gap" between their knowledge and attitudes can be bridged, and they can better appreciate each other's viewpoint.

5. EDUCATION

It was mentioned earlier that one characteristic of a useful planning model is that it must be communicable. This is partly achieved through an educational program which is another of the implementation activities and is shown in Figure 10.1 (activity 40-50). This activity requires sub-activities of selecting educational media, identifying the audience and content, and finally, making a schedule. These sub-activities will now be discussed in turn.

5.1. Media of Instruction

The most common educational media is a lecture or seminar. But in educating educational administrators on complex and comprehensive

---

1) For a more detailed discussion and for samples of the output, see Hussain (1971), pp.49-51.

educating a typically non-mathematical audience in a mathematical subject. The second problem is that of training the administrator in the use of the model and in the process of decision-making.

There are at least two approaches to the first problem of explaining a mathematical model to a non-mathematical audience. One is the TRACER used for RRPM and mentioned under validation. It traces all inputs and relationships for any selected academic program thereby enabling a user to trace "his" computations. This provides motivation for the user and gives him confidence in the model.

In one institutional implementation of RRPM, the TRACER/TRAINER is implemented on a terminal with the entire calculations of the model divided into logical units in the Programmed Instructional mode. The user can access any module and either "go back" for explanation and reinforcement or "go forward" and skip some modules if not relevant.

Another approach is to use a set of simple numerical examples to illustrate the working of the model rather than discuss the algebraic structure of the model. This approach was used successfully in the implementation of the most comprehensive of educational models, CAMPUS (Hussain, 1972). In it, the problems covered all parts of the model with numerous independent logical modules using the Programmed Instructional mode. This enabled the user to study the model at his pace and concentrate on the parts of interest to him.

Educating an administrator in the process of decision-making is most difficult. But this problem is not unique to education. It is faced by business and has been approached by business through the media of a simulation game(1). In it, the administrator is given practice in synthesizing and analyzing the output made available to him and then forcing him to make trade-offs such as he would in the real world. The game provides insights into interrelated variables and has often been very instrumental in "involving" the users and persuading them of the usefulness of the model.

Simulation games have been developed specially for higher education in both the U.S. and in Europe. The approaches to the design of the games are different and there are also different strategies in organizing and playing the game. These considerations and a critique of the games as a media of instruction is discussed in detail in Chapter 13 and therefore will not be discussed any further here.

5.2. Audience

It is very important to identify groups as the audience of the educational program that are homogeneous in their level in the

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1) For a thorough discussion see Greenlaw, et al. (1962).

will not be conducive to communication and participation.

5.3. Content

There is a core of content to which all personnel concerned with planning models should be exposed. This includes concepts of planning, modelling.MIS (Management Information Systems), PPBS (Planning, Programming, Budgeting Systems), simulation, optimization and approaches of implementation(1). Some topics are continually changing and should be topics for progress reports, especially such topics as recent developments and implementations of models in higher education as well as on the methodology of modelling in education.

Some topics should be addressed only to specific groups. Thus, the technical personnel must be told about instructional goals, objectives, and policies; planning and its role in institutional decision-making; and the technical details of the model being implemented. Likewise, management must be specifically versed on information systems; the institutional data base; and management science techniques,but without creating a "jargon barrier" and without going into technical details. The content for management's orientation should be aimed at eliminating or at least reducing typical fears of simulation models. It must be repeatedly emphasized that planning models merely provide additional relevant information designed to aid the decision-maker. It will not replace the manager and his judgement. The manager must still identify the variables that may be changed and choose from sets of consequences generated by planning models and associated with a set of alternatives.

An important function of the educational program is to identify and overcome resistance(2) to the planning model. There are many case histories of resistance to both mathematical models and to computerized data systems. In the case of many planning models there is resistance on both counts: one because it is a mathematical model, and two, because it uses computerized data systems. This resistance can be both strong and persistent. It can be passive, resulting in sabotage, rumour spreading, loss of data, etc.; or it may be active, resulting in open opposition to the use of the model.

In both cases the resistance is often the result of a fear of the unknown. This fear can be overcome by explaining the model; not

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1) For a good discussion of this topic, see Farmer (1971). It discusses the different planning models in the context of an MIS for higher education. See also Churchman (1967).

2) For a good discussion of this subject, see Zander (1960) and Caffrey (1969).

which the user can relate to, such as the use of the TRACER/TRAINER. Also, resistance arises from fear of one's data and decisions being exposed and from fear of changing roles. If the fear is unfounded it must be dispelled. If it is founded, then the changing roles and reorganization must be fully explained. This subject will be discussed further in a later section under organizational changes.

5.4. Schedule

Content will vary with the audience and this relationship can be shown in a table sometimes referred to as an Educational matrix. An example of such a matrix is shown in Figure 10.7. Some cells in the matrix are blocked-out because they are inappropriate. In the other cells priority levels can be assigned. These priority levels are then converted into dates determined by feasibility, convenience of the participants and the desired sequence of content to be presented. Sorting the dates by ascending order gives a schedule for the educational program.

5.5. Personnel for Education

Educational programs can be organized by in-house personnel or outside personnel. The latter can be expensive, but outside seminars provide contacts and an exposure to how things are done elsewhere. In-house programs have the advantage of being given by those knowledgeable about the institution and tailored more to the interest of the audience. Furthermore, they provide an opportunity to bridge the gap between developers and users. Ideally, one should have a balanced mix of outside and in-house educators. Also, it should be recognized that education is not important only during the process of implementation, but throughout the life of the planning model and its many modifications.

6. ORGANIZATIONAL CHANGES

Organizational changes (activity 10-50 in Figure 10.1) resulting from planning models have been mentioned implicitly in the last chapter. These changes concern the new emerging positions: the policy analyst and the data administrator. The need for a policy analyst is the direct result of planning models. The data administrator, however, is needed partly because of the planning model and partly for the operational information system.

There are other organizational changes necessitated by planning models. These are structural changes required to regulate the relationship between the Information Processing Center and the user as well

AUDIENCE TOPIC	Top Admin.	Middle Admin.	Institutional Research and Planning Office	Budgeting and Accounting Office	EDP Personnel	Faculty	Governi Board
Modelling in Higher Education							
Planning Models and Projects							
Resource Models and Planning							
Planning Model Output							
Model Input and Logic							
ICLM							
Exercises on Model							
Performance Indicators							
Data Base							

Top Admin.	Middle Admin.	Institutional Research and Planning Office	Budgeting and Accounting Office	EDP Personnel	Faculty	Governing Board

the planning models. These relationships are complex and need to be discussed in a separate chapter: Chapter 12.

7. SUMMARY AND CONCLUSIONS

Implementation is an important phase in the life of all models, especially comprehensive planning models. The implementation process includes the activities of data generation; running the model; validating the model; educating the user; and finally, the organization and planning for implementation. Of these activities the first two are largely the responsibility of the technical analyst. He must adapt the model (if necessary) to local equipment and must collect the necessary data. This data collection may require calculating data that is stable for prediction purposes.

Model validation involves both the technical analyst as well as the user. They must determine such factors as the strategy of validation, the experimental design aspect of the validation process, the standards of testing and the phases of testing. Also, a determination must be made as to whether the model possesses the necessary characteristics of a useful planning model: it must be credible, relevant, flexible and communicable.

In parallel to the model being tested for validity and usefulness, there is the activity of educating the user. This is perhaps the most difficult and the most important activity. It also has a long gestation period and is a continuous process which lasts the life of the system. It must itself be carefully planned as to the media of instruction, content, audience and schedule of education. Without a successful educational program the model would not be communicable and hence not useful.

Sometimes organizational changes are necessary to make the planning and budgeting process more efficient and effective, and some planning models make it necessary to have additional personnel. This would include a policy analyst who is a liaison both between the model and the user. He provides the policy parameters as input to the model and interprets the output and results.

There are some topics related to implementation that have been identified in the overview of the implementation process but have not been discussed in any detail. Their discussion has been deferred till future chapters. These topics are: simulation games used for training in decision-making (Chapter 13); structural changes needed for using planning models (Chapter 12); and finally, the generation of data from institutional files (Chapter 11). It is the last topic that will be the subject of the next chapter.

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Chapter 11

DATA GENERATION AND ADMINISTRATION

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1. INTRODUCTION

Every planning model has its unique need for data. The data must be collected and processed separately. Examples of such data and special problems of their stability were discussed in the previous chapter. In addition to this unique data, there is other data that is otherwise used for record keeping and control in most institutions. This was the experience of the eight pilot institutions that implemented RRPM 1.13 (Hussain et al., 1971:9). But the data often needs to be expanded: sometimes required in greater detail; sometimes in a historical context; and sometimes restructured by programs rather than administrative units. But in all cases, the files to be used have to be integrated. Operational needs (such as record keeping, payroll, etc.) also require integration but data for planning models need a greater degree of existing types of integration as well as additional types of integration. To achieve such integration, special linking elements are used. These linking elements and the degree and new types of integration necessitated by planning models are the subject of this paper.

Also discussed are the special roles required to administer data: the data administrator and the policy analyst.

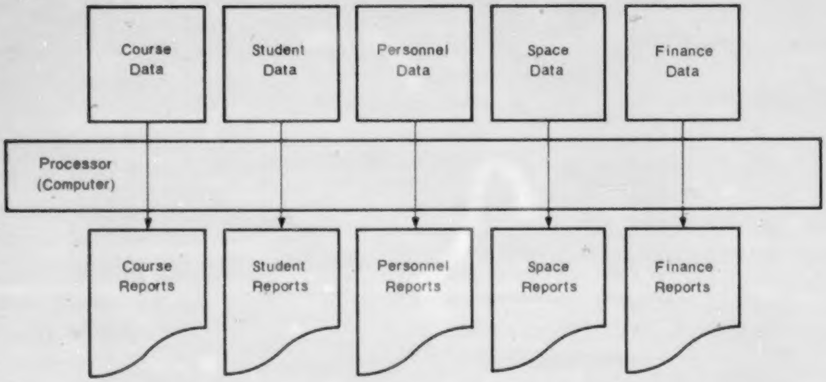
2. INTEGRATION OF DATA FILES

2.1. Need for integration

When an institution wishes to use comprehensive models of planning and budgeting, it needs considerable data which can be collected separately. But much of this data is available in most systems for operations (like payroll, record keeping, etc.), as shown in Figure 11.1. Each set of data is processed by its application program (not shown in Figure 11.1) to generate its set of reports.

For planning and budgeting the same data can be used but only if it is related. Thus, for example, to calculate the cost of a course one needs data on that course, (such as contact-hours generated), data on students attending that course, data on personnel staff teaching that course, data on space occupied by that course and other financial data for that course. This relating and unifying of data is referred to as integration and is essential both for effectiveness and for efficiency.

DATA AND REPORTS FOR OPERATION


Course
Data
Student
Data
Personnel
Data
Space
Data
Finance
Data
Processor
(Computer)
Course
Reports
Student
Reports
Personnel
Reports
Space
Reports
Finance
Reports

There are four types of integration necessary for comprehensive planning models. These are: horizontal, vertical, longitudinal and integration between all levels of planning. These will be discussed along with techniques of integration.

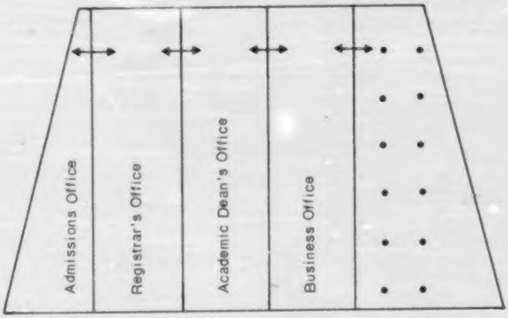
2.2. Types of integration

2.2.1. Horizontal integration

Integration at one level of administration and management is referred to as horizontal integration. It is illustrated for the operational level of administration in Figure 11.2, in which only a few organizational units are shown. Historically, each organizational unit, starting with the Business Office and followed by the Registrar's Office had their own information sub-system, including sometimes a computerized system.

Figure 11.2

EXAMPLE OF HORIZONTAL INTEGRATION


Admissions Office
Registrar's Office
Academic Dean's Office
Business Office

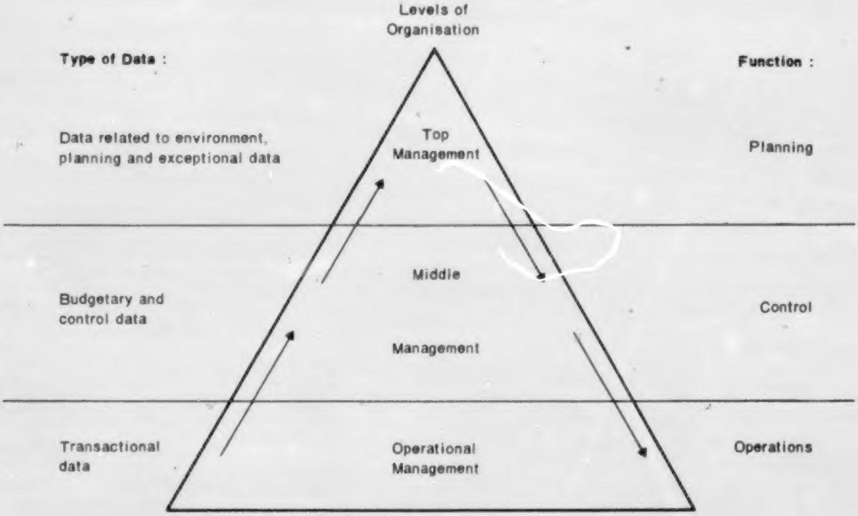
own computer personnel and their own data system. Data and information did not flow or were not exchanged between these sub-systems. This resulted not only in unrelated and inconsistent information but also in an inefficient, inaccurate and ineffective system. To overcome these problems, the systems had to be interrelated and integrated with a sharing and exchange of data and information between the sub-systems. Such a flow is shown by the horizontal arrows in Figure 11.2 (only flows between adjacent offices are shown) which gives the name horizontal integration.

2.2.2. Vertical integration

Thus far, only one level of management (an administrator) was discussed. In all institutions there are at least three levels performing different functions as depicted in Figure 11.3.

Figure 11.3

RELATIONSHIP OF TYPE OF DATA TO LEVELS OF ORGANISATION AND FUNCTIONS OF MANAGEMENT


Levels of Organisation
Type of Data :
Function :
Data related to environment, planning and exceptional data
Top Management
Planning
Budgetary and control data
Middle Management
Control
Transactional data
Operational Management
Operations

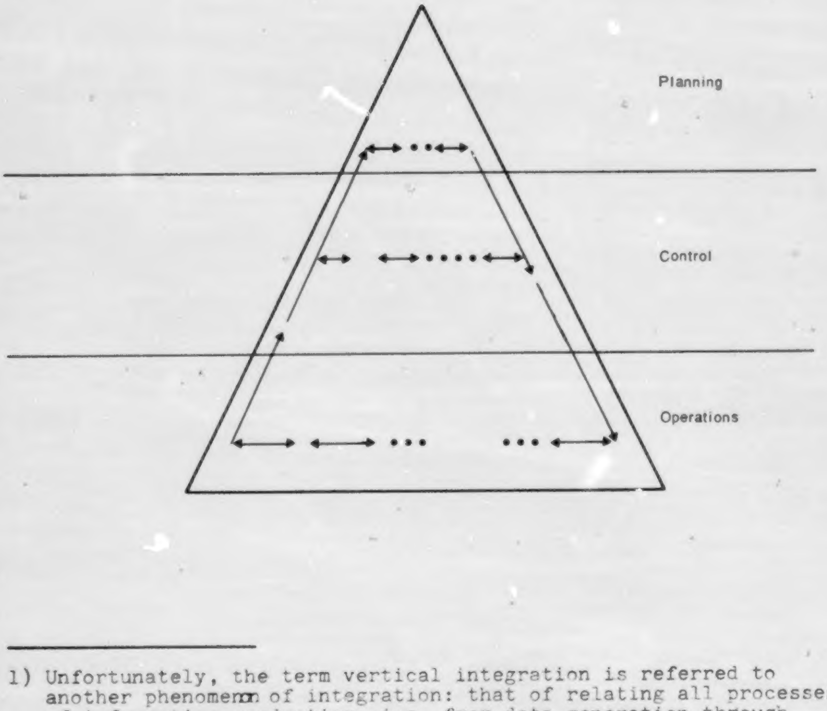
For effective management, data and information must flow between the levels of management to perform the different functions of operation, control, planning, organization and direction. This flow is depicted in Figure 11.3. Since the flow is vertical in the organization the integration resulting from such a flow is often referred to as vertical integration(1).

Figure 11.3 also shows the correspondence between the types of data required for each level of management and each function of management. Integrating data for all these functions and levels of management is part of vertical integration.

The horizontal integration shown in Figure 11.2 was at one level of management. Actually it occurs at all levels of management vertically. Combining the horizontal and vertical integration of Figures 11.2 and 11.3 we then have Figure 11.4.

Figure 11.4

HORIZONTAL AND VERTICAL INTEGRATION



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1) Unfortunately, the term vertical integration is referred to another phenomenon of integration: that of relating all processes of information production, i.e. from data generation through information usage. For a detailed discussion see Hussain (1973:74).

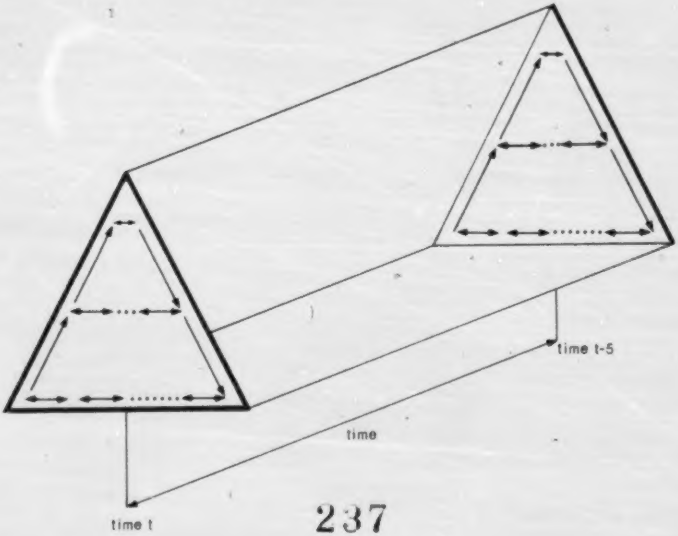
2.2.5. Longitudinal Integration

Yet another type of integration is longitudinal integration, integration over time, usually the past. Such integration of data - sometimes referred to as historical data - is very important in planning models when historical data is used for predicting values and trends in the future. Such predictions are needed not only for enrollment but also for changing planning variables such as average class sizes, ICLM, and faculty rank ratios, etc. The time period for the historical data to be integrated will vary up to ten years depending on the nature of the problem and the reliability of the historical data.

The additional time dimension of longitudinal integration when added to horizontal and vertical integration is shown in Figure 11.5. Only shown are two sets of data, one for time t and one for time t-5, or five years past. Actually there are four other "slices" of data, one for each year, or eight slices, one for each semester.

Figure 11.5

LONGITUDINAL INTEGRATION



but for some operational applications such as transcript information on a student which is kept one for each semester for five or even ten years. These needs of operations must be integrated with the longitudinal needs of planning for the same data (transcript data can be used for generating ICLM past data for planning). Thus the different types of integration are not isolated and must be coordinated. Such coordination will be discussed later, but only after discussing one other type of integration.

2.2.4. Integration at all levels of decision-making

Some data and information are confined to the institution. Examples are faculty assignments, student advisement and class lists. But some data and information cannot remain confined to the institutions. Examples are data (and information) of a planning and budgetary nature. It must be used by higher levels of decision-making, either at the regional or federal level or even at both levels. To ensure that this data is consistent with that developed and used internally by these higher levels of decision-making, it is necessary that institutionally generated data be integrated with higher levels of decision-making.

2.3. Common data base

When data is integrated in the sense described above it is referred to as a common data base, or a data bank. Like a commercial bank, any user may withdraw what he deposited, or another user deposited, provided he is authorized to do so. Unlike the unintegrated data system reflected in Figure 11.1 the common data base enables a single creation, validation and processing operation thereby improving efficiency and effectiveness.

To enable this common depository and sharing of data, there are two prerequisites. One, that the common data be uniquely defined and described (through a Data Element Dictionary); and two, that the data in the different files be linked and related together (through linking elements). These two techniques of integration will now be discussed.

2.3.1. Data Element Dictionary

To have integration of data, it is necessary that there be a standardization of the definitions of data. Any data element that occurs in more than one file and is used at more than one level of decision-making must be defined alike. This is done through a Data Element Dictionary - a DED.

institutionally defined for purposes of operations and internal control. But if the data (or information generated from it) is to be exchanged between institutions or used at higher levels of decision-making (as is the case when planning models are used), then the institutional DED must be compatible with those used by parties exchanging data or sharing the data. In the U.S., NCHEMS had DEDs developed for data elements used by statewide agencies (NCHEMS, 1974). NCHEMS has also developed DEDs for data elements used by models of planning and budgeting (Goddard, et al., 1973). Especially relevant is the development of the PCS (Gulko, 1972) the classification of programs that incorporate the classification of disciplines used by the federal government in HEGIS, the Higher Education General Information Survey.

The use of DEDs for data integration is shown in Figure 11.6. In it, each institutional file has its own institutionally defined DED which is compatible with classifications at statewide, regional and national levels. Some such classifications such as the PCS have been mentioned. Others include the national manpower Accounting Manual (Minter 1972), the Classification of Higher Education Employees by Assignment (Minter, 1971) and the Space Analysis Manuals (Dahnke et al., 1971, and Romney, 1972). For purposes of data exchange it is necessary to have data files compatible with the statewide, regional and national procedures for information exchange (Romney, 1973).

2.3.2. Linking data elements

The DED provides the common and unique definitions to facilitate vertical, longitudinal integration as well as integration at all levels of decision-making. What is needed in addition is the ability to link (relate) data in the different files to enable horizontal integration. In operational systems, the linking is typically done between two related files by one of many linking elements. They are:

1. course code
2. person identified
3. facility code
4. organizational unit code

The use of these linking codes is illustrated in Figure 11.7. Such linking, however, is not sufficient for planning and budgeting models, especially when the program approach is used. The necessary linking can be done by a program classification code (PCC) such as the PCS developed in the U.S. If such a code is included in each functional file, then we have an integrated set of data files (referred to as a data bank) and can be used for program planning and budgeting. The system could then be used as follows: for each program such as an instructional program, the output (students) can be identified from

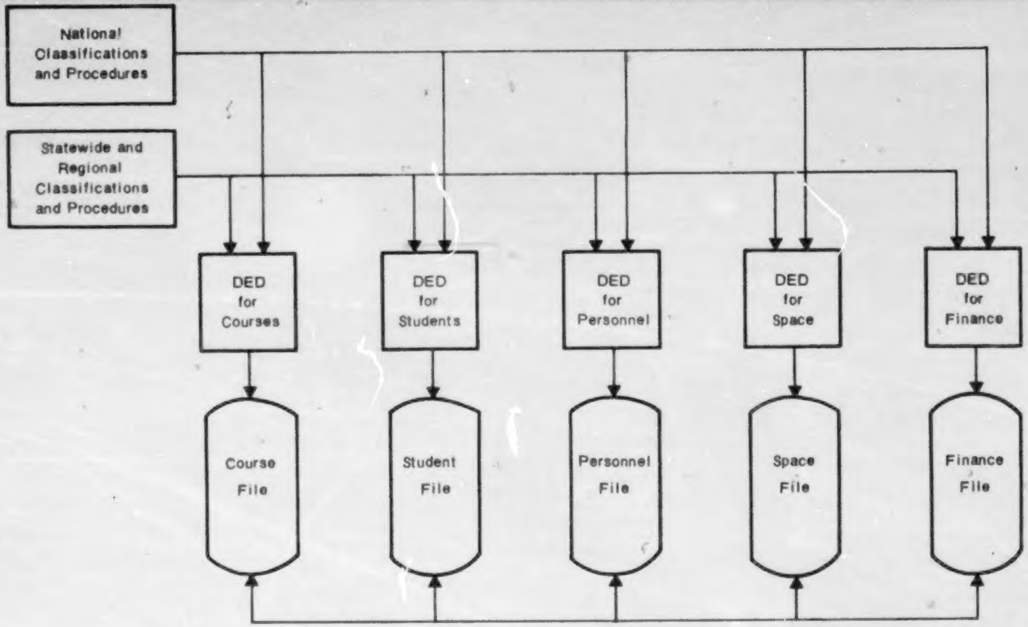
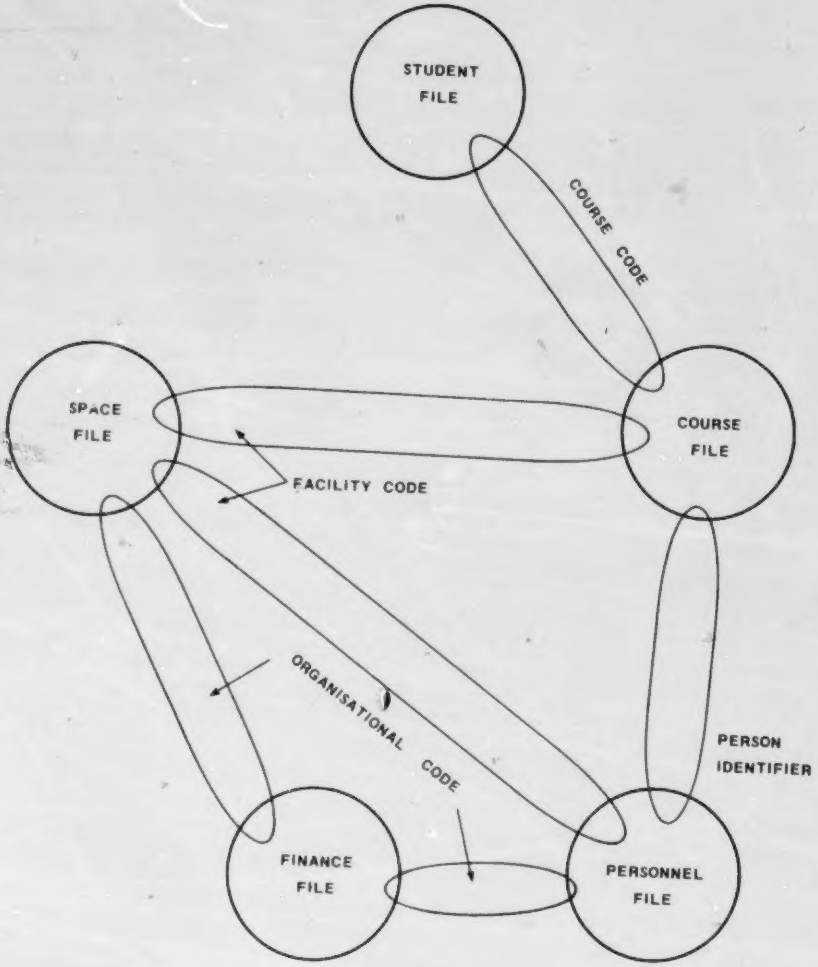

National Classifications and Procedures
Statewide and Regional Classifications and Procedures
DED for Courses
DED for Students
DED for Personnel
DED for Space
DED for Finance
Course File
Student File
Personnel File
Space File
Finance File

Figure 11.7

LINKING ELEMENTS BETWEEN TWO FILES


STUDENT FILE
COURSE CODE
SPACE FILE
COURSE FILE
FACILITY CODE
ORGANISATIONAL CODE
PERSON IDENTIFIER
FINANCE FILE
PERSONNEL FILE

identified from the Student file (for that program using its PCC); the personnel required can be found on the Personnel file (again for the program using its PCC); the space from the Space file and expenditures from the Finance file. This gives all the data required for calculating resources and output (if measurable) for each program, and achieves horizontal integration.

The linking use of a program classification code (PCC) to extract data from existing files for use as input to the planning model is illustrated in Figure 11.8. Its incorporation in each file to achieve horizontal integration along with the use of the DED which achieves the other types of integration is shown in Figure 11.9. This is a superimposition of Figure 11.8 on Figure 11.6.

3. DATA ADMINISTRATION

All common data bases - even for strictly operational needs - have a need for coordination and administration. These needs, however, increase with planning models, especially the needs for maintenance, data security and data control. These needs are being met by an emerging new position, that of the Data Administrator. His role and his functions will now be discussed.

3.1. Data administrator

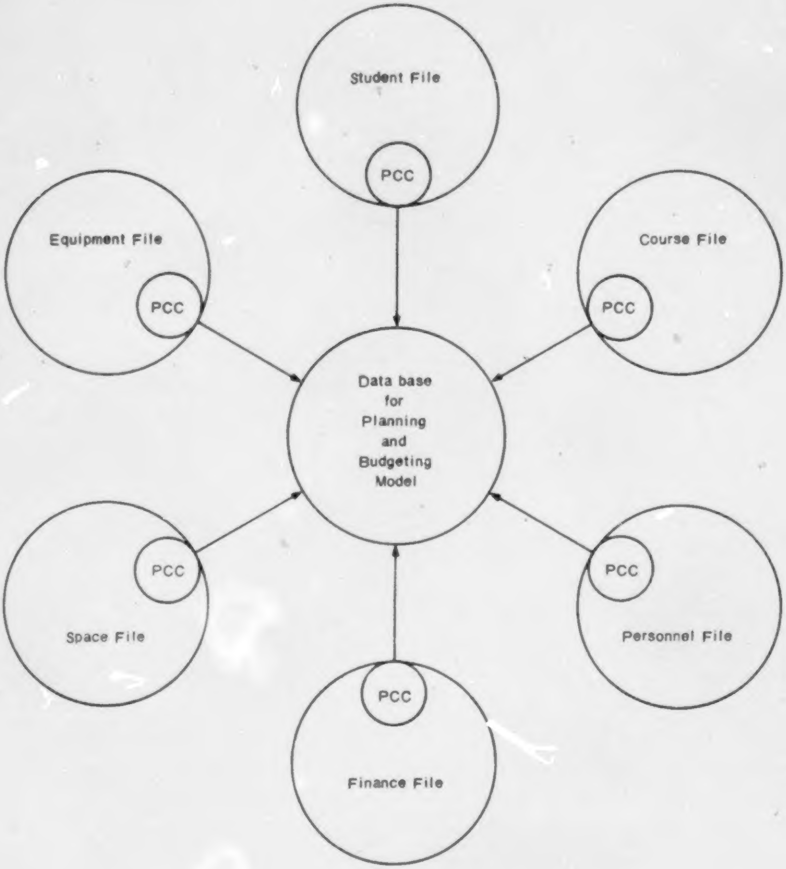
Data maintenance is a very important function of a data administrator and data administration. It requires the constant upkeep of active data, the storing of historical data and the purging of useless data. Data must constantly be moved between devices and storage media and must be carefully logged and tagged for fast and effective access.

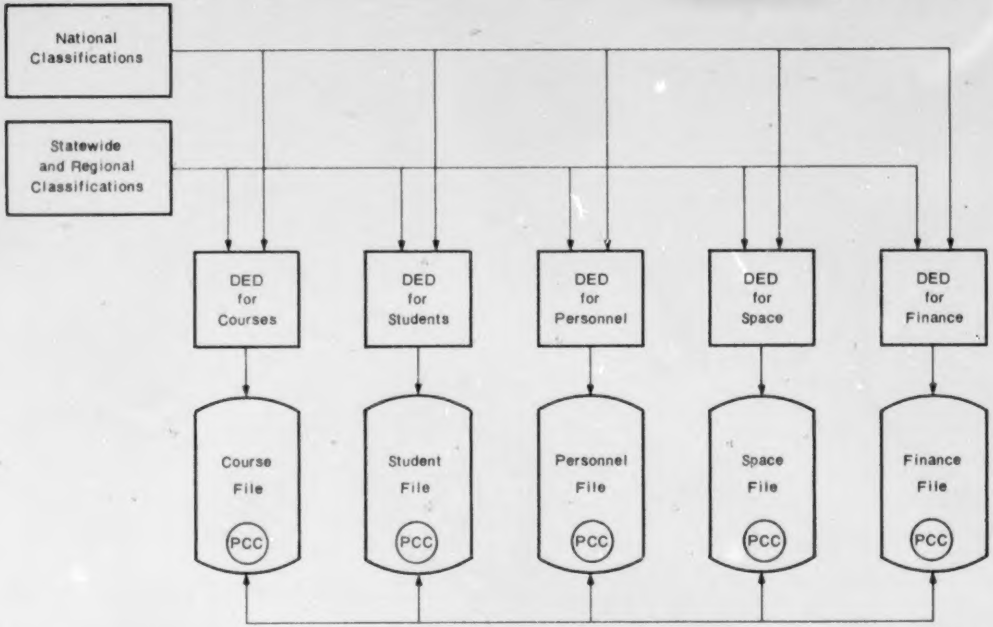
Data maintenance includes adjusting to changes in the Data Element Dictionary and Data Directories (used for identification and references to data elements).

Data maintenance also includes having the data complete and continuous. The continuity is very important for planning data as was discussed under longitudinal integration. This requires making changes to historical files when definitions of data elements or classifications change. For example, if a department of education were divided into two departments of Physical Education and Education then this change must be reflected in historical data if this data were needed on a longitudinal basis. All changes in classifications and coding must be controlled. Integrity of data is especially crucial in on-line systems. There, a break in processing could result in loss of data. Procedures for back-up and recovery and restart must be established in all such events of breakdown including natural disasters.

Figure 11.8

USE OF PCC FOR LINKING FILES


Student File
PCC
Equipment File
PCC
Course File
PCC
Data base for Planning and Budgeting Model
PCC
Space File
PCC
Personnel File
PCC
Finance File


National Classifications
Statewide and Regional Classifications
DED for Courses
DED for Students
DED for Personnel
DED for Space
DED for Finance
Course File
PCC
Student File
PCC
Personnel File
PCC
Space File
PCC
Finance File
PCC

Related to integrity is the problem of accuracy and reliability of data. The data base must be monitored for the desired level of quality. Logging and auditing procedures must be established and followed. Performance (on access, utilization, cost, response time) must also be monitored.

Another important function in data administration is that related to the privacy (misuse of data) and security (unauthorized use of data). The security is important especially with planning model data since it is sensitive by nature, has many creators and users. The authorized ones must be distinguished from those unauthorized.

Security can be achieved through passwords, passkeys or other methods of uniquely defining authorized users. The data to be accessed, the time of access, the place of access (such as a terminal) can also be specified. Policies and procedures governing security must be described and enforced. This is a responsibility that is important and growing.

The functions of the data administrator as discussed above and a few other functions are summarized in Figure 11.10.

3.2. Policy analyst

Thus far we have discussed the personnel required to create, maintain and monitor the data base. But personnel is also required to analyze the data base and interpret it for the user. This is especially true in data bases that store both raw and derived data such as data bases used for planning models. The data in such cases has many analytical uses which need to be identified and interpreted to the user. Such analyses have both descriptive and prescriptive value and are important by-products of data bases used for planning models. One example of such a by-product occurred in the pilot implementation of RRPM-1. One user indicated that the greatest use of RRPM was not the projected budget but an analysis of the ICLM used for projecting the budget (Hussain and Martin, 1971:71).

The need for such analysis and interpretation of data is resulting in another emerging position...what Tom Mason calls a policy analyst (Mason, 1973:3-4). A policy analyst's role is to analyze output as well as input. For institutions using planning models the policy analyst must also analyze existing historical data for possible use as planning variables in the planning model. In such models important examples of input data include the ICLM, average class loads, average class sizes, and average room utilization. In addition, in the case of the ICLM and student transition matrices, the matrices must be analyzed for stability and integrity. In the case of Faculty load coefficients, the data must be analyzed for reasonableness and consistency. Such analyses can lead to many separate projects and

Figure 11.10

FUNCTIONS OF A DATA BASE ADMINISTRATOR

Data Base Design

- Content
    - creation
    - reconciling differences
- Dictionary/Directory
    - create
    - maintain
- Data Classification/Coding
- Data Integrity
    - backup
    - restart/recovery

Data Base Operation

- DED Custodian/Authority
    - maintain
        - add
        - purge
- Data Base Maintenance
    - integrity
    - detect losses
    - repair losses
- Security/Access
    - assign passwords
    - assign lock/key
    - modifying passwords/keys
    - logging
    - cryptography
    - modification
- Statistics
    - access
    - frequency of processing
    - space use
    - user utilization
    - response time
- Design operational procedures
    - access to Data Base
    - access for testing
    - interfaces
    - testing system

Monitoring

- Quality of data
    - validity
- Performance
- Efficiency
- Cost
- Use/Utilization
- Security/Privacy
- Audit
- Compliance
    - standards
    - procedures

Other Functions

- Liaison/Communication with
    - end users
    - analysts/programmers
- Training on Data Base
- Consultant on File Design
- Design Operational Procedures
    - access to Data Base
    - access for testing
    - interfaces

models such as the Faculty Activity Analysis, the Course Load Generator, and the Space Utilization Model. All these analyses could logically be the function of the policy analyst.

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Chapter 12

ORGANIZING FOR PLANNING MODELS

CONTENTS

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1. INTRODUCTION

Planning models affect the flow and content of information. Large amounts of data must be collected and analyzed by different agencies in the institution. This requires a high degree of coordination and communication if the process is to be efficient and effective. Especially affected are the Office of Planning and Budgeting and the Office of Institutional Studies. Planning models raise a number of questions concerning their functions and organizational relationships. Which office has the line responsibility and which has the staff responsibility for the planning model and planning information? Which office reports to the other or do they both report to a higher level? Where should the planning data be processed? Should it be processed at the administrative processing center where most related data is stored or at the research computing center which has the more appropriate computing equipment? Who monitors and controls the data? If it is the data administrator, which office (including the Computing Center) should the data administrator report to? And to which office does the policy analyst report? And to which office should the research teams report? What should be their composition and functions relative to planning model development? These and other related questions are the subject of this chapter.

Since planning models greatly affect the process of planning, it will be desirable to first describe this process. Within this context, the questions raised above will be answered and in the following order: Organization Structure for Planning, Offices of Planning and Budgeting, Information Processing Center, Office of Institutional Research and Research Teams.

2. THE PLANNING PROCESS

The planning process(1) using a comprehensive planning model (especially one like CAMPUS) is shown in Figure 12.1. In it are identified offices and agencies that perform a function related to planning. The actual titles of such offices and agencies, of course, will vary between institutions and between countries. In some cases

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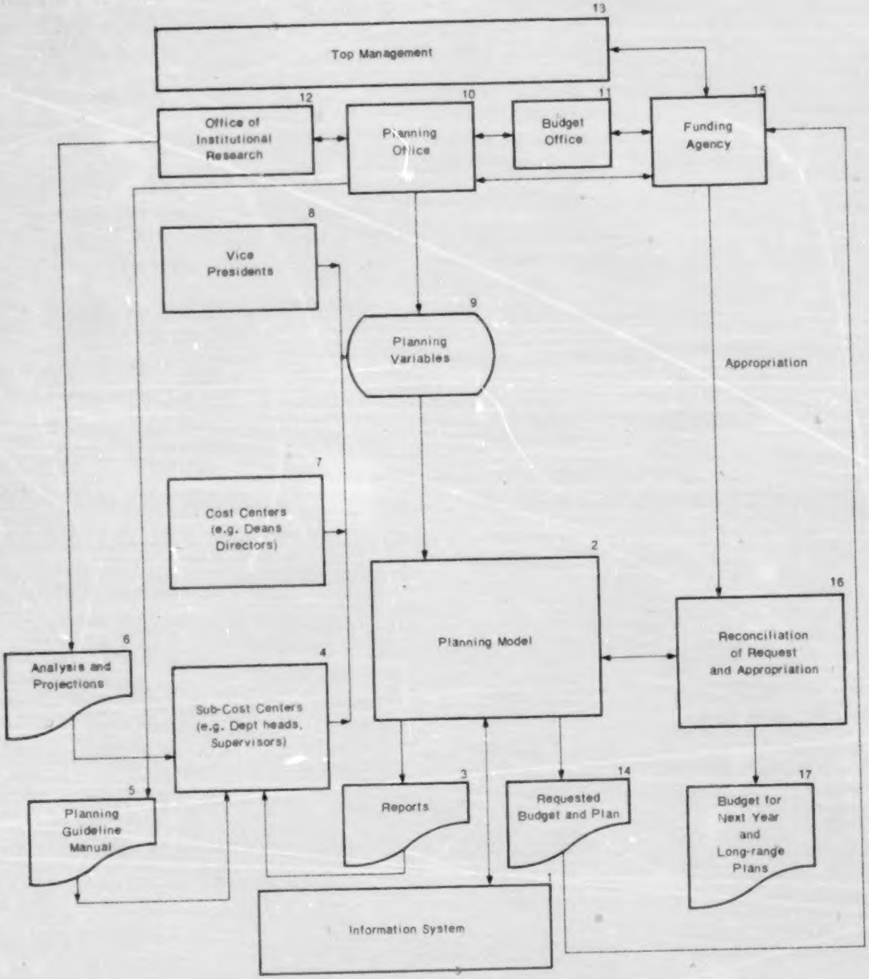
1) For excellent discussion of planning and techniques of planning, see Lockwood (1972 (a) and (b)).

PLANNING PROCESS USING A COMPREHENSIVE PLANNING MODEL


13
Top Management
12
Office of Institutional Research
10
Planning Office
11
Budget Office
15
Funding Agency
8
Vice Presidents
9
Planning Variables
Appropriation
7
Cost Centers (e.g. Deans Directors)
2
Planning Model
16
Reconciliation of Request and Appropriation
6
Analysis and Projections
4
Sub-Cost Centers (e.g. Dept heads, Supervisors)
5
Planning Guideline Manual
3
Reports
14
Requested Budget and Plan
17
Budget for Next Year and Long-range Plans
1
Information System

than one. We shall be concerned here with a typical generic situation.

The planning process is a continuous one. At any one moment in time, there is analysis of the past; preparation of the budget request for next year; and long range plans and projections being made for future years. But for purposes of discussion, let us start with the beginning of an academic year. Data of last year from the information system (box 1 in Figure 12.1) is used in the planning model (box 2) to generate reports (symbol 3). These are sent to the Sub-Cost-Center (box 4) along with Planning Guidelines prepared by the Offices of Planning and Budget and with Analytical Reports and Projections (symbol 6) made by the Office of Institutional Research. This information is used for preparing budget requests which are consolidated at the Cost Center level (box 7) and finally at the Vice President level (box 8). In this process of consolidation (for both academic and non-academic cost centers) the administrative offices may interact with the planning model and ask "what if" questions. The extent of such participation will depend on the procedures existing and resource available. In any event, planning variables (symbol 9) will be determined. These will be reviewed by the Planning Office (box 10), the Budget Office (box 11) and analyzed by the Office of Institutional Research. They in turn will determine further institutional planning variables which will reflect the goals, objectives and priorities of top management (box 13). The model will then be run and its reports(1) will be analyzed. More interaction with the model will simulate the consequences of the alternative strategies and the calculations of trade-offs. The resource requirements are compared with resources available and with estimates of the benefits. The recycling with the model eventually results in the selection of one strategy that then determines the request operating budget and capital budget (symbol 14). These are sent to the funding agency (box 15). This may start another cycle of using the model; more questions, more data from the information system, more output from the model and further analysis by the Offices of Institutional Research, Planning and Budgeting. More hearings and deliberation by the Funding Agency. Finally there is an appropriation. Typically this must be reconciled with the budget request and long range plan (box 16). This may involve another cycle with the model resulting in a final budget and long-range plan (symbol 17) which then becomes the basis for next year's operation. And then the cycle for another year starts anew.

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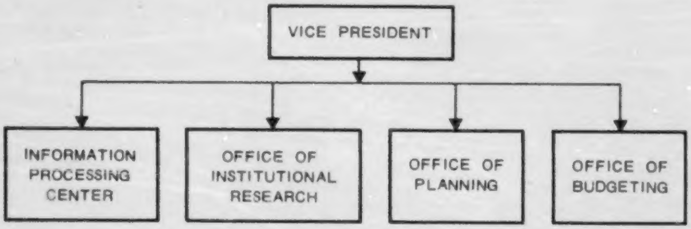
1) For a discussion of the nature of reports from Simulation Models, see Fincher (1968).

3. ORGANIZATION STRUCTURE FOR PLANNING

From the above discussion of the planning process it becomes clear that some offices and agencies are very closely related to the process of planning and budgeting. These offices are: Office of Institutional Research, Office of Planning and the Office of Budgeting and the Information Processing Center. These offices need to be closely coordinated. One framework for such coordination is shown in Figure 12.2. In it, all these offices report to a Vice President.

Figure 12.2

ORGANISATION STRUCTURE FOR PLANNING


VICE PRESIDENT
INFORMATION PROCESSING CENTER
OFFICE OF INSTITUTIONAL RESEARCH
OFFICE OF PLANNING
OFFICE OF BUDGETING

This level of reporting is crucial. It enables the coordination of all activities related to planning and budgeting to reside at a level within one level of the President. It also enables participation in top policy-making and decision making. Such top-level participation is necessary as observed by numerous studies (Garrity, 1963:10 and Reichenbach and Tasso, AMA Report No.92).

4. OFFICES OF PLANNING AND BUDGETING

The close relationship between planning and budgeting is fairly well recognized. In PPBS, the two are integral parts of the same technique. As stated by Farmer (1970:1), planning is "the selection or identification of the overall, long range objectives of the organization and the systematic analysis of various courses of action in issues of relative costs and budgets". Budgeting is "the translating, planning and programming decisions into specified plans". Programming is in between, and is the "deciding on the specific courses of action to be followed in carrying out planning decisions". In functional terms, the Planning Office is typically responsible tion and consequently includes the function of space management. The Budgeting Office, on the other hand, is concerned more with the short-range matters of making the budget for the next years. Both offices are assisted by the Office of Institutional Research (Mason, 1967: 29-40) in determining the related planning factors as well as for analysis in interpreting the output.

There are many planning factors and these may be closely related to the goal of the institutions. In many cases the goals are intertwined with objectives, constraints, values, prejudices, motives, expectations and opinions. The goals and objectives must be operationally defined. This is very difficult in an academic community of trained scholars who are independent and strongminded. Difficult as it may be it must be done. Priorities must be assigned. Assumptions must be stated, debated, accepted or rejected, revised or added upon. A consensus must be reached. In many institutions and countries it is more a political process than an economically rational one. But it must be done. And it may well be done by the Office of Institutional Research. They must help the process of finding agreement by which conflicting values in the institution are resolved (Mason, 1970:31-36).

Sometimes this is in the form of an unspoken compromise of conflicting forces acting within and upon an institution. They result in rewards for some and deprivations for others. It is a subtle way of assigning institutional priorities but an important and effective way nonetheless. Both offices are big users of the Information Processing Center that generates such output. Consequently a close relationship between these offices at the same organization level as shown in Figure 12.2 is highly desirable.

5. INFORMATION PROCESSING CENTER

Planning models are big users of Information Processing Centers: as a user of the processor for computing; and as a user of data. The institutional data maintained at the Information Processing Center contains many data elements required by the planning models. But this data needs to be extended for use by the planning models: in greater detail, or rearranged and related with other data. This extension is relatively simpler and cheaper than having to generate the data separately. However, in many universities there is not the necessary communication between the Information Processing Center and the planning model users. Consequently, all the model data has to be collected separately, validated separately, and even stored separately. This results in much duplication of data and effort and is a tremendous waste of organizational results besides leading to inconsistency of tutional data is owned not by the creator or biggest user but by all institutional users. Furthermore, it is necessary to have an organizational relationship between the Information Processing Center and the planning model, such as the one shown in Figure 12.3.

In Figure 12.3, the planning model is identified as a user though it has no organizational entity as such. Its needs are channelled either through the Offices of Planning, of Budgeting or Institutional Research. But it is a main user in terms of the large amounts of data and computing time used.

In Figure 12.2, one centralized Information Processing Center is assumed(1). In many institutions of higher education, there are at least two such centers, one for administrative use and one for academic (instruction and research) use. In such cases, the user of the planning model is attracted towards both: he is attracted to the administrative center for that is where the institutional data base resides, and he is attracted to the academic center because of its faster computing facility. Speed is very important in planning models,especially simulation models. Therefore organization access to both computing facilities is important and desirable.

Another problem related to computers is that of pricing. Many academic computing centers wish to charge for administrative use. (This happened at the Universidad Nova de Lisboa.) Pricing at commercial rates then makes the use of simulation on models very expensive. Their running cost can be justified when the computer cost is considered a sunk cost. Hence pricing computer's time must be such that simulation models are economically feasible.

Another problem related to processing is that of maintaining, monitoring and controlling the data base. These were considered part of the functions of the Data Administrator. The question is: who should the data administrator report to?

Since the work of a data administrator is technical and processing oriented, he could follow functional lines and report to the Information Processing Center. However, many users argue that the data administrator should report to his supervisory committee (which could be a Users' Committee). This would enable the committee to control related data processing functions better and at the same time give the user the feeling of being the "custodian" of the data base. Furthermore, to perform his functions the data administrator must have authority over the data base as it relates not only to users in all organizational units but also users at all levels of the organizational hierarchy. This authority under the direction of a supervisory committee extends even over vice-presidents and data processing

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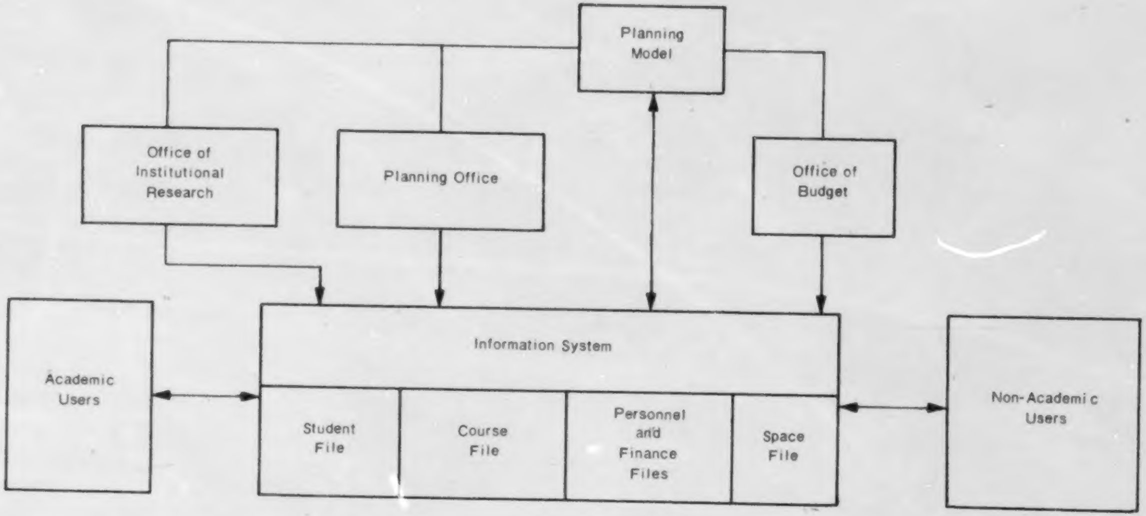
1) For an analysis of such a structure see Chaney (1969).

Figure 12.3

INFORMATION PROCESSING CENTER RELATING WITH USERS


Planning Model
Office of Institutional Research
Planning Office
Office of Budget
Academic Users
Information System
Student File
Course File
Personnel and Finance Files
Space File
Non-Academic Users

personal financial gain. This was found in a study by the Stanford Research Institute. A table from this study is shown in Figure 12.4.

Figure 12.4

EMBEZZLERS BY POSITION OF EMBEZZLER

Position	Number of Embezzlers*
Operations Vice-President, manager, clerk	32
Loan officer, manager	29
Teller	22
President	14
Cashier	8
Director, stockholder, officer	5
Vice-President, EDP	4
EDP clerk	3
Bookkeeper	3
Trust officer	3
Programmer	3
Computer operator	3
Systems analyst	2
Chief teller	1
Vice-President	1
Proof Department supervisor	1

* Includes 17 cases of collusion

Also, to perform these functions the data administrator needs powers akin to what Lyon calls a "government of the data base with both legislative and executive powers (Lyon, 1971:11-13)". The legislative role would include power to make rules regarding content definition, access control, security, recovery, logging, dumping and auditing of data. The executive action includes the monitoring and enforcing of rules especially as it concerns security and privacy of data, as well as efficiency and effectiveness of the data base.

To govern the data base and perform the many functions listed in Figure 11.10, the data administrator needs many talents. The data administrator of the OASIS System at Stanford recommends that a data administrator be a "...technician, politician, consultant...who speaks with equal fluency the languages of both computers and human beings" (Traver, 1973:8).

It is difficult to find all of these qualities in any one person. However, data administrators generally have assistance in managing large data bases. They can select a balanced staff to include all these qualities among the staff personnel. In addition, the staff personnel should have expertise as data specialists, as trainers/ educators and in public relations and liaison work.

Another agency concerned with the generation of data and information is the Office of Institutional Research (Mason, 1971:176-177; Mason, 1967). In a study done around 1965, Rourke and Brooks found that 43 per cent of the Directors of Institutional Studies perceived their major role as being that of data gathering (Rourke, et al., 1966:2). Some of this data is unrelated to planning (such as "basic" research in the learning process as well as student and faculty behaviour); some is related to planning but outside the institutional data base required for record-keeping; and the remainder is data gathering related to the existing institutional data base. This last category of data gathering is either an overlap of effort already done with the institutional base or it is effort that could be done at a lower marginal cost if integrated with the institutional data base. Thus the Office of Institutional Research is performing (and most likely still performing) a task that is resulting in much duplication and waste of institutional resources. This can be avoided by having a close organizational relationship between the Offices of Institutional Research and the Information Processing Center as shown in Figure 12.2.

In the discussion of the institutional data base we saw that there is information outside the institutional data base that is required as input to the planning model. Some of this, however, still needs the institutional data base for its basic data. Examples of this would be future projections of enrollment and non-salary expense. These must be projected using historical data in the data base along with other relevant data both internal and external to the institution. (Other examples of data for the planning model that uses historical data are the statement of estimation equations and the estimation of the estimation coefficients.)

Other planning model data are not in the institutional data base and must be determined externally. Some of these will be educated guesses or will be collected from sampling experiments. Sometimes a special study would be necessary. An example would be the distribution of faculty effort. Such data can be collected by interviews or questionnaires which require a careful experiment design and implementation. This must be done as a separate special project, either regularly or periodically.

Other inputs to the planning model are future planning variables. Examples are average class size, course loads and teaching load distribution. These could be determined at the cost-center level but typically the Office of Institutional Research is called upon to provide projections and analysis to serve as a basis for making such determinations. The Institutional Research analyst must then add qualitative information to the existing hard data to integrate decision making with the complex political and social environment. This kind of information, perhaps better called intelligence, is vital in translating data into information. It is necessary in determining the planning factors and it is very essential since it is the planning factors that largely determine the output of the model.

Once all planning factors are determined, the planning model can be run (assuming other input is pre-determined); output will then be generated. These must be checked for accuracy and consistency. Then they must be analyzed, interpreted and evaluated. Here again, Institutional Research can perform an important function. It must temper the computer printouts with subjective judgement, intuition and intelligence. It must examine the many dimensions that are not recorded in computer memory because they are subjective and qualitative in nature. As a result, sometimes, interpretation and evaluation must rely on inferences and assumptions based on judgement and experienced intuition. In communicating this evaluation, researchers must identify the assumptions as clearly as possible. The decision makers can then judge from their experience the validity they will grant to the assumptions, modifying them where necessary.

Frequently there is disagreement over assumptions which will lead (time and resources permitting) to special research into the issue to secure more data, more opinions and attitudes or more comparative information to provide a better basis of justifying the assumption. This leads to more special projects for Institutional Research providing a better basis for decision-making.

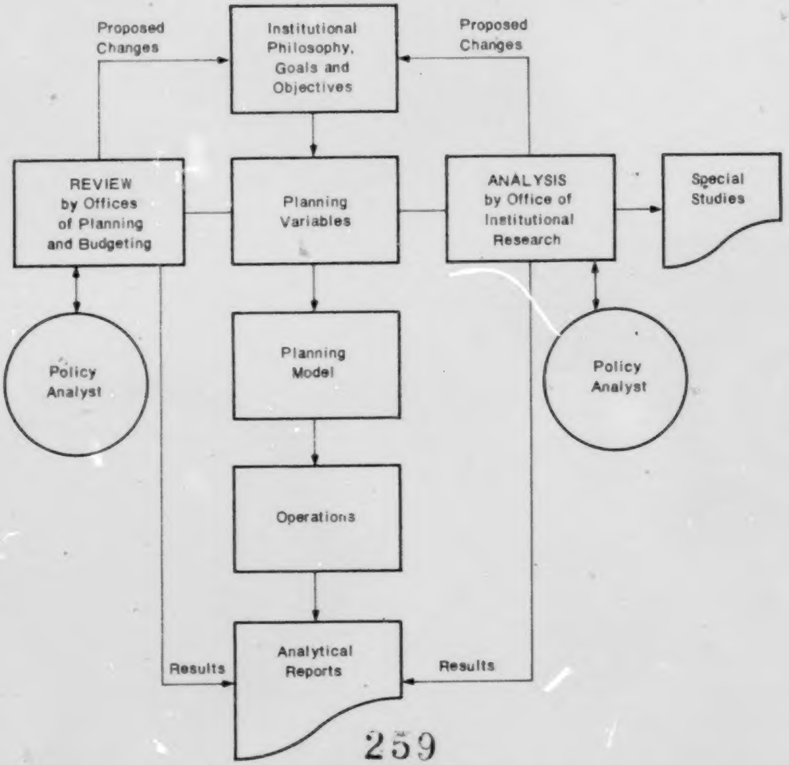
In evaluating the consequences of a strategy in the situation mode it is theoretically necessary to measure the benefits. Unfortunately, the state of the art does not enable us to satisfactorily measure benefits (Micek, et al., 1972 and Lawrence, et al., 1970). And yet we must find proxies to benefits and add intelligence to our evaluation. For the most part, this kind of evaluation is the only means we have to assess the benefit side of the cost equation. Without the evaluation of qualitative, often intangible benefits, resource allocation policy would be little more than bookkeeping.

In summary, the role of Institutional Research in the planning process consists of: participating in the design and maintenance of the institutional data base so as to ensure that it provides some of the data necessary for the planning model; generating through special studies some of the remaining data required by the planning model; helping the decision maker along with the Offices of Planning and Budgeting in transforming institutional goals into planning factors; and finally, helping in interpreting and analyzing the input and output by critically evaluating the benefits and effectiveness of the alternative strategies. In performing this role, the Office of Institutional Research must work very closely with the Offices of Planning and can best be done through an organizational relationship shown in Figure 12.3.

The relationship between the Office of Institutional Research and the Offices of Planning and Budgeting will vary with institutions. It is largely a function of the personalities involved and the historical evolution of the offices in the institution. Typically, however, the Office of Institutional Research will be a staffing support role to the Offices of Planning and Budgeting (along with other agencies of the institution). The Office of Institutional Research will do the analysis required for the review of proposals made to the Offices of Planning and Budgeting. They will then make the changes necessary to the planning variables and propose changes to institutional philosophy, goals and objectives. These are then articulated as operational objectives to be used by the planning model. These relationships are shown in Figure 12.5.

Figure 12.5

ROLES OF THE OFFICES OF PLANNING, BUDGETING AND INSTITUTIONAL RESEARCH


Proposed Changes
Institutional Philosophy, Goals and Objectives
Proposed Changes
REVIEW by Offices of Planning and Budgeting
Planning Variables
ANALYSIS by Office of Institutional Research
Special Studies
Policy Analyst
Planning Model
Policy Analyst
Operations
Results
Analytical Reports
Results

both the Offices of Planning and Budgeting as well as to the Office of Institutional Research. This could be two persons, one in each office or one person working with both offices. The choice will depend on the size of the institution, the complexity of the planning model, and the personalities involved.

7. RESEARCH TEAMS

Some work related to institutional research can be done by research teams(1) working on a research project. Such projects could work on planning models or submodels such as discussed in Part One and Chapter 8. Alternatively, the projects could be on planning methodology, the design of data sub-systems, or the evaluation of models and techniques of planning.

The amount of research time would be a function of the complexity of the project, as well as the time and funds available for the project. The team's composition should whenever possible be a balance of persons having idealism and realism: theoretical knowledge and practical experience; sensitivity to behavioral as well as quantitative approaches, and finally, the inside knowledge of the organization as well as the objectivity of an outsider. In terms of professional background, a planning model related project would typically include an economist especially for projects involving costing or benefit analysis; a statistician especially for projects with stochastic variables like the Student Flow Model or projects involving prediction and estimation; a computer scientist where much data and computer programming is involved; and also an operations researcher who is versed in the methodology of quantitative research.

It is difficult to hire personnel with such talents for any project. Instead one acquires personnel temporarily in a matrix organization (Cleland, 1968:172). Under this concept, selected personnel are assigned (full-time or part-time) to the project only for the duration of the project and return to their work after the completion. A diagrammatic representation of such matrix assignments are shown in Figure 12.6.

One group unique to the university and not fully recognized for their potential to research teams are the faculty. They not only represent an important sector of the university but often have the knowledge if not the experience. Furthermore they can identify as well as attract students to work for the project. This not only gives students some experience in working in research teams but gives the research project some "cheap labor". The use of students and faculty have been used very successfully in many planning model projects by universities such as the one in Linz, Austria.

---

1) The concept of research teams is well known to Operations Research (Churchman, et al., 1957:9-11, 21-22 and 57-65).

Figure 12.5

MATRIX ORGANIZATION OF PROJECT TEAMS

Project	Offices of Planning and Budgeting	Offices of Institutional Research	Business Office	Faculty	. . . . .	Outside Consultant
A	X	X		X		
B	X	X				X
N	X	X	X	X		X

8. SUMMARY AND CONCLUSIONS

To implement planning models and to substain them in the post-implementation period, it is sometimes necessary to make structural changes to the organization. The most important of these arise when the many agencies involved in planning are not coordinated. This occurs in institutions that have separate offices of Planning (that makes the long range plan), the Budgeting Office (that executes the budget) and the office of Institutional Research (that analyzes and generates some data necessary for the planning models). All these offices need to be coordinated to prevent overlap as well as the danger of their working at cross-purposes.

Another set of problems relates to processing. In many institutions, the administrative processing unit dealing with functional files is administratively separate from the unit responsible for planning. Consequently much of the raw data required by the two units is collected separately. This leads to considerable overlap and duplication resulting in a waste of institutional resources, as well as a loss of control and coordination that is necessary. What is required therefore is a coordination (not necessarily a centralization) of such processing resources. Structural changes must be made to enable all agencies working with planning models (Office of Planning, Budgeting and Institutional Research) to share the processing facilities of the institution and to avoid jurisdictional conflicts.

Another problem sometimes arises with computer processors. Some institutions have an administrative computer that is adequate for maintaining administrative files and generating reports while the instructional and research computer is appropriate for scientific computations and often has large memory. A Planning Office using a large comprehensive model needs to use both computing facilities. Typically these facilities report to different and rival administrative heads. It then becomes necessary to organizationally coordinate these services so that the users of planning models have access to both facilities. Also, the pricing of computing should be such that planning simulation models are still economically feasible.

All the structural problems discussed above occurred in one university in the U.S. that implemented CAMPUS. The necessary reorganization involved the replacement of an operational manager, an appointment of a new top administrator, and the reshuffling of many titles, roles and organizational lines of authority. This process was slow and very painful. But it was necessary in order to rationalize the process of planning and budgeting and to make it more efficient and effective. If these organizational problems are recognized and anticipated, then the resulting changes could be less painful and more orderly.

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Chapter 13

GAMING MODELS IN HIGHER EDUCATION

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1. INTRODUCTION

This manuscript is addressed to the manager and administrator in higher education. It concerns the use of games and gaming, which are simulated decision-making. More specifically, we are concerned with the use of games in situations of resource allocation for budgeting and long-range planning.

Section 2 starts with basic definitions and concepts (including definitions on games and gaming). This is followed by a discussion of the scope and nature of games and its development.

Two games are identified as being currently used in higher education. These are USG and RRPM 1.6. They are discussed in some detail in Sections 3 and 4 respectively, followed by their evaluation and comparison in Section 5. Finally in Section 6 there is an evaluation of games: their uses and limitations.

For further study there is an annotated bibliography to complement the many citations to specific references made as footnotes in the text.

There is reference material in the appendices. It includes an annotated guide to the extensive literature on RRPM 1.6. There is no such material easily accessible on USG and hence this appears in the Appendices. It includes a systems flow chart and a listing of the computer program to enable the reader to run USG himself. Also included is a numerical solution to complement the discussion of the logic in the text.

The games discussed are mathematical and computerised. However, there are no prerequisites in mathematics or computer science required of the reader. All concepts needed are developed from elemental and primitive terms used in higher education. These concepts are illustrated by means of block diagrams.

2. BASIC DEFINITIONS AND CONCEPTS

2.1. Definitions

A common use of the word "game" is the activity played for pleasure and recreation such as chess, chequers or dominoes. In this monograph we are also concerned with a game, but one of a very serious nature. In it the participants (called players) work in groups (called teams) on a problem. They take decisions of an economic nature such as level of price, the rate of work or production and the allocation of resources. The results of these decisions are calculated as if the decisions were made in real life. Based on these results (called feed-back) the teams make further decisions. Again, they are informed of the results knowing whether they made good decisions or bad decisions. In a sense then, this type of game is a decision-making-laboratory much like a science laboratory. In it, one can experiment such as not allowed in real life and make mistakes without the implications of the costs of such mistakes were they made in real life. Also, the decisions are made rapidly without waiting for months or years as one would in real life. Thus the results of decisions of many years of real life can be compressed into a short time. The real world is simulated and imitated but, in spite of the artificiality of the game world, there is learning resulting from the playing of the game.

There are other benefits of such games and these will be discussed later along with examples of such games in the context of their historical development. First, however, we need to define some other terms that are similar or related.

One is gaming. This is the use of games as defined above but distinct from *operational gaming* that is concerned with the finding of optimal solutions. These terms(1) are also distinct from the "Theory of Games" which is concerned with optimal economic behaviour and enunciated by von Neuman and Morgenstern.

2.2. *History of Games*

The earliest games were the Prussian War Games. The formal economic games of the type to be discussed in this monograph started with the AMA Game (2) in 1957. In the next four years there were over 100 such games(3) largely business games, played by over 30,000 executives(4). The game first to be used in a university environment was the University Administrator's Decision Laboratory(5) by IBM.

---

1) For a further distinction of games and related terms, see Rapoport, A., *Fights, Debates and Games*, or its French translation *Combats, Débats et Jeux*. Translated by Thébaudière, J. de la, Paris: Dunod 1961.

2) Ricciardi, Franc M. et al., *Top Management Simulation: The AMA Approach*, New York: American Management Association Incorporated, 1957.

3) For a description of many of these games, see Kibbee, J.M. et al., *Management Games*, New York: Reinhold Publishing Corporation, 1961.

4) Meier, R.C., et al., *Simulation in Business and Economics.* Homewood III: Richard Irwin, 1969, p.182.

5) Klaproth, W.W., *University Administrator's Decision Laboratory*, 360 version 1966, S/360 General Program Library, 360 D-15.1.001.

There have been other educational games(1) including one by Jim Gunnel(2) who was interested more in faculty recruitment and decision-making,and one by Forbes(3) which was concerned with tuition rates, hiring of faculty, salaries, admissions standards, assignment of load, or the acquiring of equipment and space. But none of these games were concerned with how changes in curricula affected resources required. They did not use the programmed concept of output nor did they use the PPBS (Program Planning and Budgeting System) approach for calculating the next year's budget and the long range plan. This had to wait till the late '60s and the acceptance of the PPBS concept into higher education along with the development of program budgeting models. In this context we can define a model as an abstract representation of a situation. In this case the model was a mathematical model where mathematical statements were used to represent outputs resulting from a set of inputs or decisions. Repeatedly running this model would "simulate" or "imitate" reality.

Such models of simulation developed for higher education in the late sixties and early seventies. They include models like CAMPUS, CSM, RRPM, HELP, CAP:SC that were developed in the U.S. and HIS and TUSS developed in Europe. But these models were fairly complex in structure and the concept of models and simulation were new to administrators in higher education. To train them on the structure and use of the model, it was necessary to develop gaming models that would be somewhat simpler than those to be used in actual decision-making. These models have since been used quite extensively and are the subject of the remaining part of this monograph.

There are many such games that have been designed and used. Some have been superseded by more recent versions. Currently, only two exist. One is USG (University Simulation Model) and the other is RRPM 1.6 (Resource Requirement Prediction Model, 6th version of model 1).

USG is the simpler of the two models. It corresponds to only part of RRPM 1.6. And this is the first part, which makes it logical to discuss USG first. This is done in Section 3, followed by a discussion of the extension of USG in RRPM 1.6 in Section 4. In both

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1) For a list and discussion of educational games see Derick Unwin "Simulation and Games" in Tansey P.J. (ed.), Educational Aspects of Simulation. London, McGraw-Hill, 1971, pp.247-267.

2) Gunnel, J., "University Faculty Recruitment: A Man Machine Game" in International Journal of Theory Design and Research, Vol.11, No.3, September 1971, pp.349-375.

3) Forbes, J., "Operational Gaming and Decision Simulation" in Journal for Educational Measurement, Vol.2, No.1, June 1965, pp.15-18.

that is necessary to play the game and appreciate its capabilities.

3. USG MODEL

3.1. Introduction

USG was developed at the University of Utrecht in the Netherlands. It was designed to train people in the use of TUSS, the model actually used for resource planning and budgeting at the University. The main difference is that TUSS starts at the much more basic and detailed level of the courses taken by students and from it develops the load on the instructional personnel. Then, at the second level it calculates resources and some resource indices. It is for this second level that USG is designed. The game has been played not only by university administrators but also by students. At Utrecht, the students participate in university management and USG is designed to provide them (along with management) with an understanding of the variables involved and their interrelationships.

The main calculated results of the USG are as follows:

- . Surplus or shortage of teaching hours
- . Salary cost for teaching
- . Teaching cost per student
- . Student/staff ratio
- . Staff/assistant ratio
- . Curriculum quality index

Note that we are basically concerned with resources and these are limited to resources in teaching. Given these resources we calculate ratios and indices to measure certain criteria. This is done for each "faculteit" or academic department. In the game, all the teams will be typically playing for the same department in order to be able to compare their performance.

But how are the output calculations made? What are the decision-variables or control variables (values determined and "controlled" by decision-maker) and parameters (values fixed and not controlled by decision-maker)? What are the assumptions and definitions involved? What is the significance or use of these calculations?

The answers to the above questions is the topic of this chapter. It will be attempted through a set of diagrams (Figures 13.1 - 13.8) of the flow of input and output, identifying by special symbols all the decision variables, parameters and outputs. These parameters and decision variables are also listed in one of the appendices on USG.

3.2. The logic of USG

In calculating resources required for teaching, USG takes the position that teaching personnel have three main responsibilities: teaching, research and "other" activities which include administrative work and public service. But the research and "other" activities are difficult to calculate or estimate directly. Therefore they are assumed to be a fraction of teaching effort. Thus the teaching effort becomes crucial to the USG model.

Teaching is done by two types of personnel: teaching staff who are professional teaching employees, and student assistants who are temporary employees. These are referred to as "instructional staff". In addition, there is staff employed in curriculum development who do not actively teach though they are typically teachers by profession. In USG they are personnel involved in developing and improving programs for self instruction. They are more a development investment rather than operational recurring teaching costs.

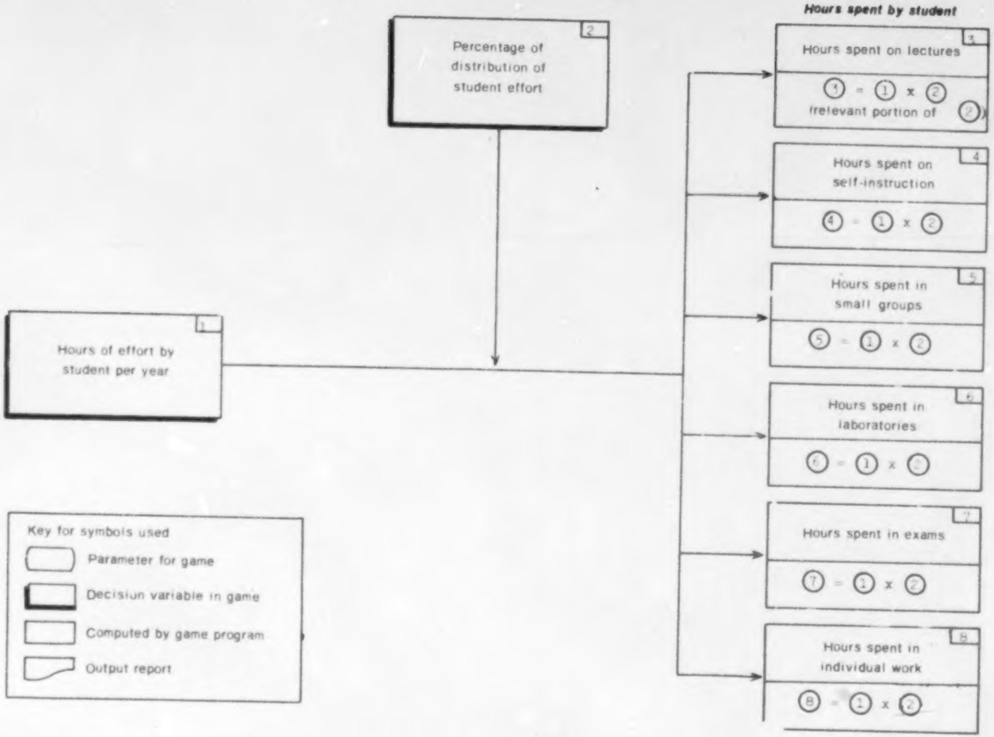
The instructional resources are considered a direct function of the effort by each student in that academic department. This is shown in Figure 13.1 where one starts with a decision variable of the hours spent by each student (box 1 identified by the number on the top right hand corner of the box). Another decision variable is the distribution of the student effort in six different activities. These activities are:

1. lectures
2. self-instruction
3. small groups
4. laboratories
5. exams
6. individual work.

This percentage distribution (box 2) when multiplied by the hours of effort by each student per year (box 1) gives the hours spent in each of the six different activities (boxes 3-8).

These hours of effort are converted to teaching resources required, but different types of effort have different rules of computation. There are three of these types of effort. One includes lectures and self-instruction. This is independent of the number of students involved but is dependent on the number of levels of students. These are discussed in Figure 13.2. The second type includes small groups and laboratories that are dependent on the number of students and maximum class-size. This type is discussed in Figure 13.3. And finally, there is the third type that is only dependent on the number of students. This type is discussed in Figure 13.4. Each figure will now be discussed in turn.

STUDENT'S EFFORT DISTRIBUTION


Hours spent by student
2
Percentage of distribution of student effort
1
Hours of effort by student per year
3
Hours spent on lectures
③ = ① x ②
(relevant portion of ②)
4
Hours spent on self-instruction
④ = ① x ②
5
Hours spent in small groups
⑤ = ① x ②
6
Hours spent in laboratories
⑥ = ① x ②
7
Hours spent in exams
⑦ = ① x ②
8
Hours spent in individual work
⑧ = ① x ②
Key for symbols used
Parameter for game
Decision variable in game
Computed by game program
Output report

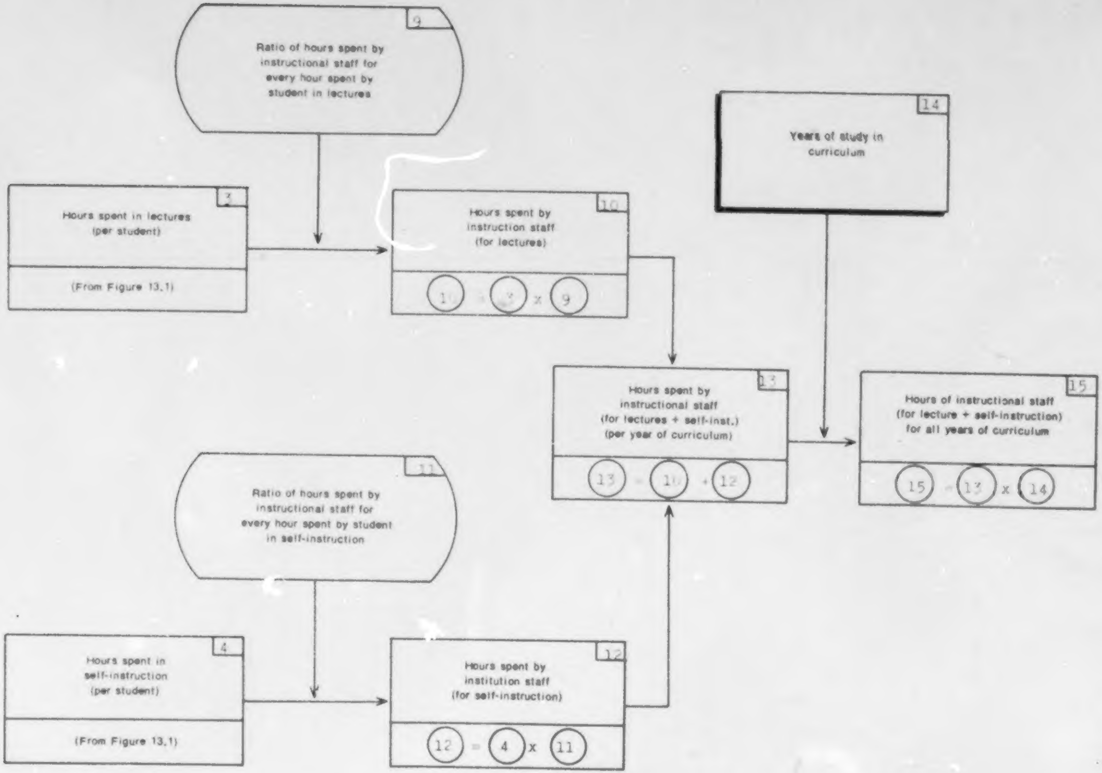
The hours spent in lectures by a student (box 3 in Figure 13.2 and calculated in Figure 13.1) is multiplied by the ratio of instructional staff hours per hour of student (oval box 9) to give the hours spent by instructional staff for lectures (box 10). The calculation is represented as 10 = 3 x 9 in the box 10. Similarly, the hours spent in self-instruction per student (box 4) when multiplied by the ratio of hours of instructional staff for each hour by student (oval box 11) gives the total hours of instructional staff for self-instruction (box 12). When this is added to the hours spent on lectures (box 10), we get the total hours spent by instructional staff on lectures and self-instruction (box 13).

In these sets of calculations we have used parameters for the first time. These were the ratios of hours spent by instructors per hour by student in lectures and self-instruction (oval boxes 9 and 11 respectively). In the TUSS model, these would be decision variables. In the game version USG, their values are fixed and hence they are parameters. This reduces the number of decision variables in the game. It may reduce the flexibility of the game but it makes the game faster to run and conceptually simpler to comprehend. Also, if there are too many decision-variables that are changed in each play of the game, then it is difficult to identify which variable or relationship caused the change in output. For these reasons the game designer retains the important game variables (necessary for a realistic environment) as decision variables and fixes the remaining values as parameters. This is the prerogative of the designer based on his objectives and perception of the environment that he wishes to simulate. He always has the problem of selection so as to balance realism of the environment with simplicity and ease of playing the game within specified boundaries of the environment. However, if a user wishes to change the environment, or some of the parameters with decision-variables, he can theoretically do so. It would involve some computer reprogramming and changing the input forms.

Back to Figure 13.2. The hours spent for the instructional staff calculated (box 13) was for one year since the hours of effort per student we started with (box 1) was for 1 year. This is assumed (perhaps a heroic assumption) to be the average for all the levels of the student. Thus the total instructional hours for the institution (box 15) would be the hours per year (box 13) multiplied by the number of levels of the student which is the same as the years of the curriculum (box 14).

Note that the instructional effort is a function of the hours spent by each student. This implies independence of the number of students involved. This relationship is somewhat obvious for self-instructional activities like courses taught through CAI (computer-aided-instruction), programmed instructional texts, TV or audio-

CALCULATIONS FOR LECTURE AND SELF-INSTRUCTION


9
Ratio of hours spent by instructional staff for every hour spent by student in lectures
3
Hours spent in lectures (per student)
(From Figure 13.1)
10
Hours spent by instruction staff (for lectures)
10 = 3 x 9
14
Years of study in curriculum
13
Hours spent by instructional staff (for lectures + self-inst.) (per year of curriculum)
13 = 10 + 12
15
Hours of instructional staff (for lecture + self-instruction) for all years of curriculum
15 = 13 x 14
11
Ratio of hours spent by instructional staff for every hour spent by student in self-instruction
4
Hours spent in self-instruction (per student)
(From Figure 13.1)
12
Hours spent by institution staff (for self-instruction)
12 = 4 x 11

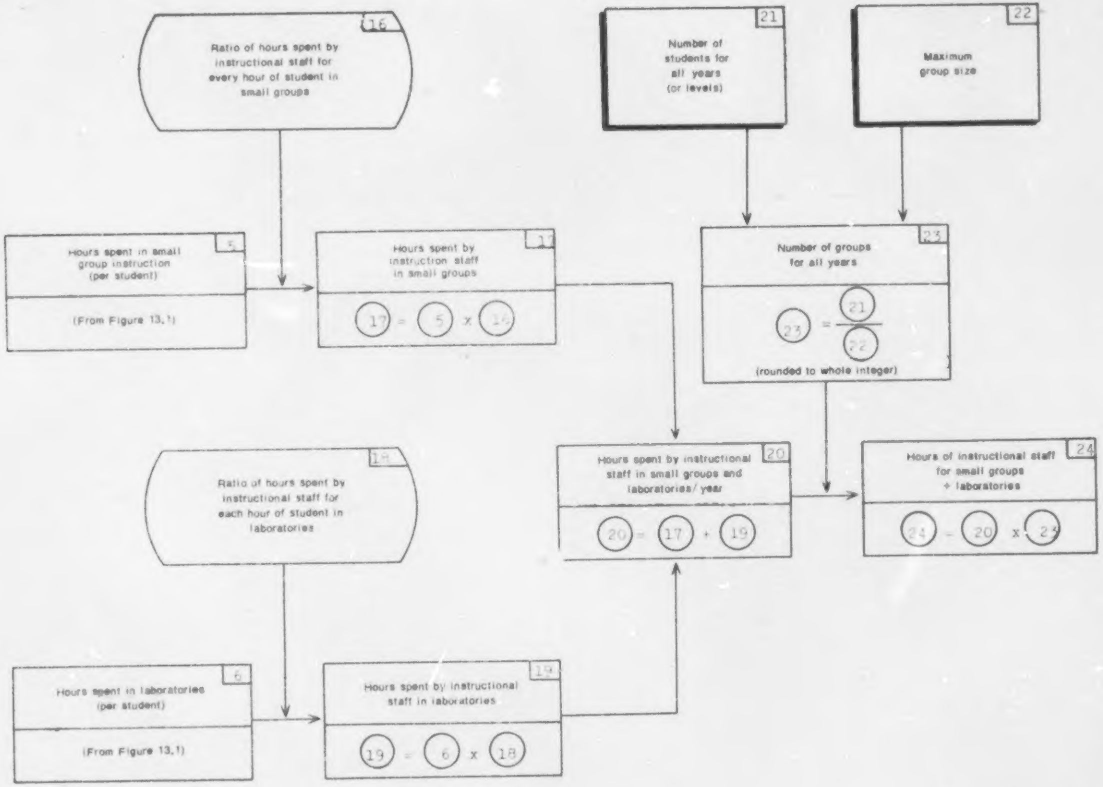
(classes. But in lectures (i.e. class meetings) there is typically a size consideration. In USG, however, the number of lectures is independent of the number of students. It is always one (i.e. the more students in the class, the larger the class room but still only one "lecture"). If, however, size is important or significant, then it is no longer called a "lecture" but rather a "small group" or a "laboratory", the latter typically requiring equipment and work of a practical nature. These types of meetings have staffing needs that must be calculated differently and this is shown in Figure 13.3.

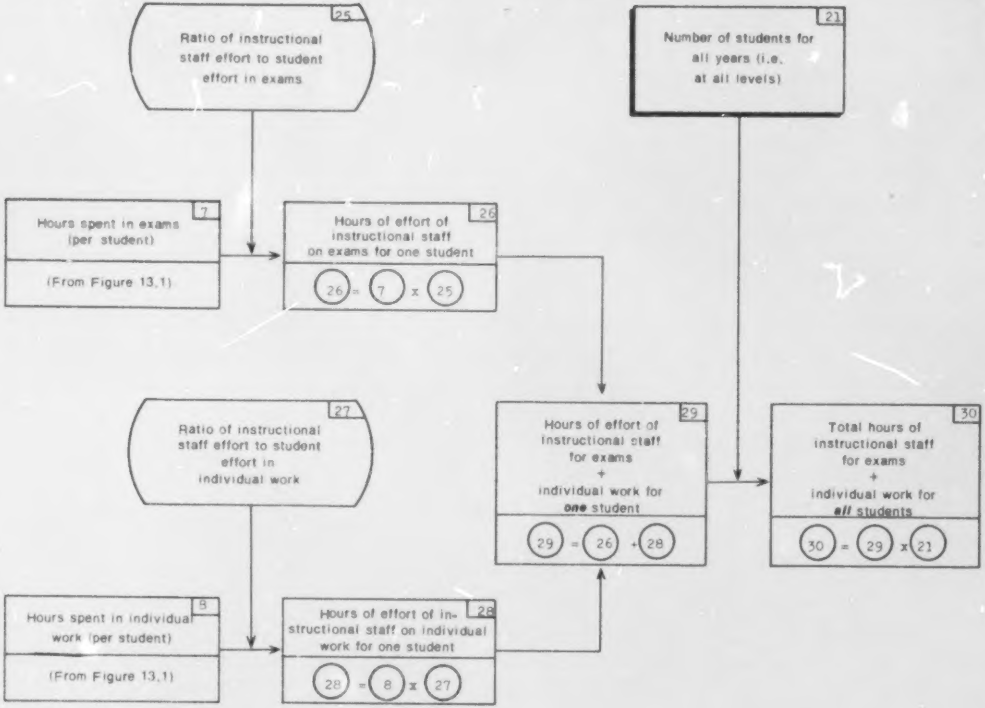
With small groups and laboratories we start off as with lectures and self-instruction. We take the hours spent by students in small groups and laboratories (boxes 5 and 6 respectively) and multiply each by its ratio of hours spent by instructional staff to student (oval boxes 16 and 18 respectively) to give the hours spent by instructional staff in small groups or in laboratories (boxes 17 and 19 respectively). These when added together give the hours spent by instructional staff in groups and laboratories (box 20). This value, however, is for all the students assuming they were in one group. But by definition, small groups and laboratories are size dependent. Thus the hours spent by instructional staff (box 24) will be the hours spent by instructional staff (as in box 20) multiplied by the number of groups of small groups or laboratories (box 23). The number of groups is the total number of students (for all the levels of students) (box 21) divided by the maximum group size (box 22). These latter two values are decision variables in the game, but note that the maximum class size in USG is independent of the level of student. Typically this decreases as the level of student increases i.e. the average maximum class size for the 4th year is typically smaller than that of the 3rd year or certainly less than the 1st year student. Note again, an important assumption.

We now have the last category of student effort: exams and individual work. This is shown in Figure 13.4. Again we take the time spent by each student (boxes 7 and 8) and multiply it by the ratio of instructional staff effort to student effort (oval boxes 25 and 27 respectively). Adding the two components for exams and individual work (boxes 26 and 28) we get the total instructional effort for exams and individual work (box 29). (Individual work includes such activity as thesis writing, excursion, etc.).

The effort calculation (box 29) is for one student since the initial value of effort (boxes 7 and 8) was for one student. We must therefore multiply this (box 29) by the total number of students at all levels of the curriculum (box 21), which is a decision variable, to give us the total hours of instructional staff resulting from the responsibilities of exams and individual work (box 30).

CALCULATIONS FOR SMALL GROUPS AND LABORATORIES


16
Ratio of hours spent by instructional staff for every hour of student in small groups
21
Number of students for all years (or levels)
22
Maximum group size
5
Hours spent in small group instruction (per student)
(From Figure 13.1)
17
Hours spent by instruction staff in small groups
17 = 5 x 16
23
Number of groups for all years
23 = 21 / 22
(rounded to whole integer)
18
Ratio of hours spent by instructional staff for each hour of student in laboratories
20
Hours spent by instructional staff in small groups and laboratories/year
20 = 17 + 19
24
Hours of instructional staff for small groups + laboratories
24 = 20 x 23
6
Hours spent in laboratories (per student)
(From Figure 13.1)
19
Hours spent by instructional staff in laboratories
19 = 6 x 18


25
Ratio of instructional staff effort to student effort in exams
21
Number of students for all years (i.e. at all levels)
7
Hours spent in exams (per student)
(From Figure 13,1)
26
Hours of effort of instructional staff on exams for one student
26 = 7 x 25
27
Ratio of instructional staff effort to student effort in individual work
29
Hours of effort of instructional staff for exams + individual work for *one* student
29 = 26 + 28
30
Total hours of instructional staff for exams + individual work for *all* students
30 = 29 x 21
8
Hours spent in individual work (per student)
(From Figure 13,1)
28
Hours of effort of instructional staff on individual work for one student
28 = 8 x 27

We can now add all the components of instructional staff effort (boxes 15, 24 and 36) to give us the total instructional staff effort in hours of teaching (box 31 in Figure 13.5). This effort required must be compared with the effort available to give the shortage or surplus of effort. The effort available is first calculated in terms of full-time-equivalent persons (i.e. FTE). This is done by adding the teaching staff available (box 32) and student assistants available (box 33). Both these are decision-variables. Their summation gives us the total instructional staff available for teaching (box 34) in FTE. Note that this does not include the staff for curriculum development because in the model they do not teach as such.

The FTE available must now be multiplied by the average hours of work per FTE per academic year (oval box 35) which is a parameter in the model. This multiplication gives the total hours of instructional staff available (box 36). But not all this effort available goes to teaching (part of it goes to research and part to "other" activities). To determine the effort available for teaching (box 38) we need to multiply the hours of instructional staff available (box 36) with the ratio of time of instructional staff available for teaching (box 37) which is another decision-variable.

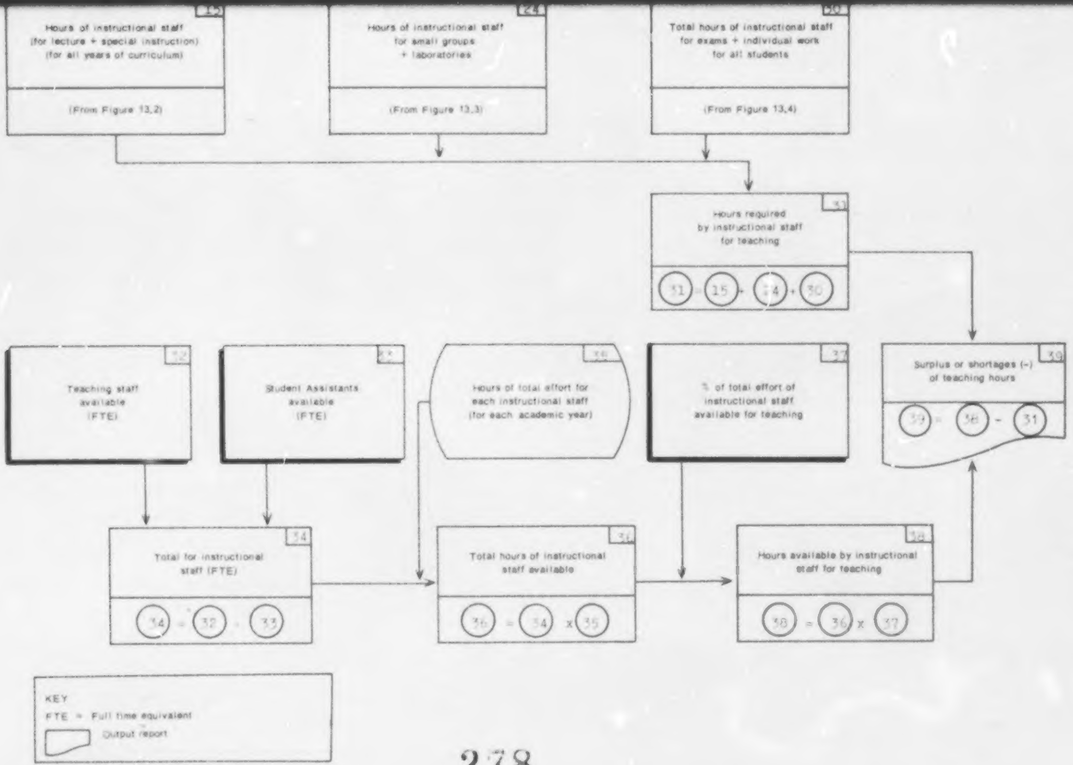
The teaching hours (of instructional staff) needed for teaching (box 31) is then subtracted from the hours available (box 38) giving a surplus (if positive) or a shortage (if negative). This is a result that appears in the output (output report symbol 39).

We shall now discuss the calculations of the different ratios shown in Figure 13.6. First the student-staff ratio. Staff here is defined as all staff available for instruction, i.e. teaching staff (box 32), student assistants (box 33) and in curriculum development (box 40). All these are decision variables. This total staff (box 41) is divided by the total number of students (at all levels) (box 21) giving a student staff ratio (output symbol 42).

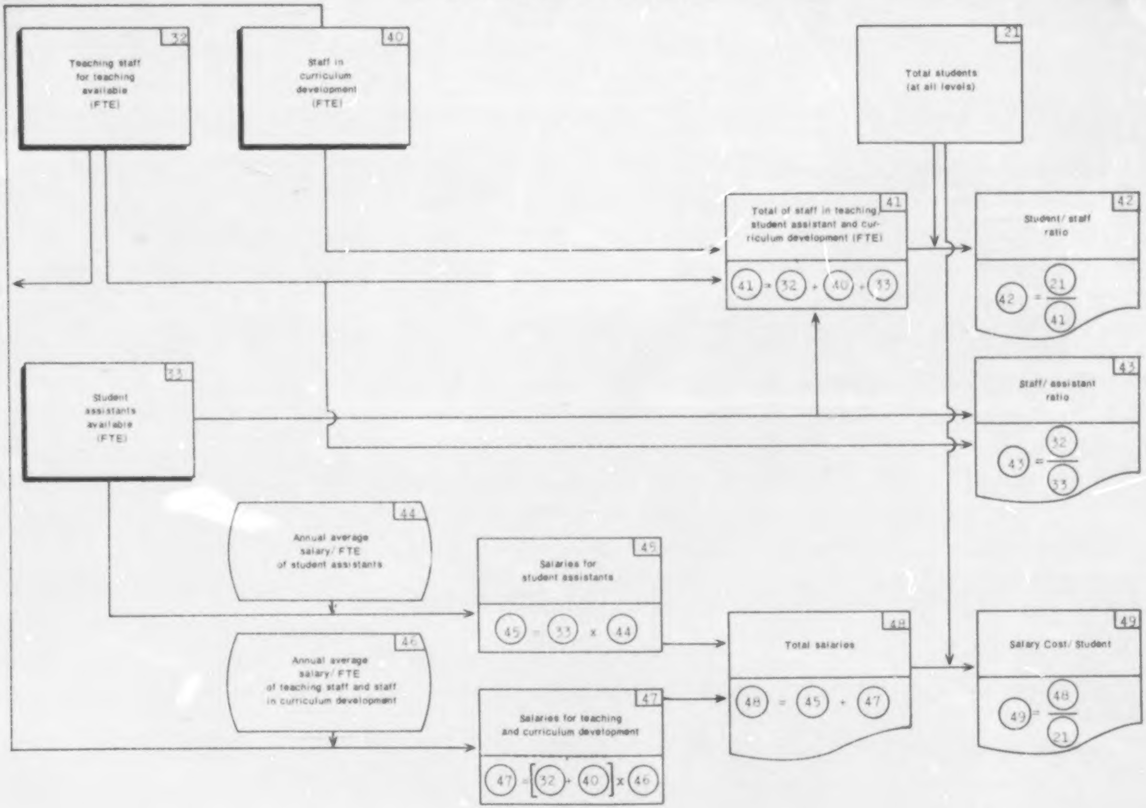
In the staff-assistant ratio, staff is defined as only the teaching staff available (box 32). This divided by the student assistants available (box 33) gives the staff-assistant ratio (output symbol 43).

The final ratio is cost per student. The cost here is only the salary costs. There are two average annual salary rates. One for teaching staff and staff in curriculum (oval box 46) which when multiplied by the sum of teaching staff (box 32) and curriculum staff (box 40) gives the salaries for teaching and curriculum staff (box 47).

Note that in this calculation we assumed no ranking amongst the staff for purposes of salary. Only one average salary for all staff is assumed. One may argue with the assumption but the designer had the trade-off between simplicity and realism. The more the realism,


15
Hours of instructional staff (for lecture + special instruction) (for all years of curriculum)
(From Figure 13.2)
24
Hours of instructional staff for small groups + laboratories
(From Figure 13.3)
30
Total hours of instructional staff for exams + individual work for all students
(From Figure 13.4)
31
Hours required by instructional staff for teaching
31 = 15 + 24 + 30
32
Teaching staff available (FTE)
33
Student Assistants available (FTE)
35
Hours of total effort for each instructional staff (for each academic year)
37
% of total effort of instructional staff available for teaching
39
Surplus or shortages (–) of teaching hours
39 = 38 – 31
34
Total for instructional staff (FTE)
34 = 32 + 33
36
Total hours of instructional staff available
36 = 34 x 35
38
Hours available by instructional staff for teaching
38 = 36 x 37
KEY
FTE = Full time equivalent
Output report

CALCULATION OF RATIOS AND COSTS


32
Teaching staff for teaching available (FTE)
40
Staff in curriculum development (FTE)
21
Total students (at all levels)
41
Total of staff in teaching, student assistant and curriculum development (FTE)
41 = 32 + 40 + 33
42
Student/staff ratio
42 = 21 / 41
33
Student assistants available (FTE)
43
Staff/assistant ratio
43 = 32 / 33
44
Annual average salary/FTE of student assistants
45
Salaries for student assistants
45 = 33 x 44
46
Annual average salary/FTE of teaching staff and staff in curriculum development
47
Salaries for teaching and curriculum development
47 = [32 + 40] x 46
48
Total salaries
48 = 45 + 47
49
Salary Cost/Student
49 = 48 / 21

the greater the complexity and less the simplicity. The designer chose simplicity without hopefully giving up much realism. The model could be expanded later to add realism and hence complexity(1).

The other salary cost component is for student assistants. This is determined (box 45) by multiplying the student assistants in FTE available (box 33) by the annual average salary for student assistants (oval box 44). This salary rate and the rate for the other staff are both parameters.

Adding the salaries for student assistants (box 45) with the salaries for teaching and curriculum development (box 47) gives total salaries (box 48) which when divided by the total number of students at all levels (box 21) gives the salary cost per student (output symbol 49).

We have one more set of calculations. This concerns the "curriculum quality". It has two components: one is the weighted hours spent by each student and is shown in Figure 13.7; the other concerns class size and curriculum years. This is shown in Figure 13.8.

The first component is the multiplication of the hours spent in each activity by each student (boxes 3-8) with its respective weights (oval boxes 50-55). The sum of all these weighted values gives a quality score (box 56).

The weights are parameters. For example, typically there would be a higher weight for small groups than for lectures. This assumes that instruction would be better in small groups and hence the quality of the curriculum (or the educational program) would be more enhanced.

The other consideration of curriculum quality is that of group size. This is shown in Figure 13.8. The quality score is calculated by the following formula:

Quality score = No.of hours spent by student in small groups and laboratories/year) x 0.5 x 15 - maximum group size for small groups and laboratories).

In other words, as the group size increases the quality score drops because a larger maximum group size is considered directly proportional to lower quality of curriculum.

In Figure 13.8, the quality weighting formula for group size is shown (in oval box 57); the maximum group size (box 22); the hours spent in small groups (box 5); and in laboratories (box 6) are used to calculate the quality score for group size (box 58). This when summed with the quality score for student effort distribution (box 56) gives the combined quality score for effort and group size (box 59). This must be multiplied by the length of curriculum in years (box 14)

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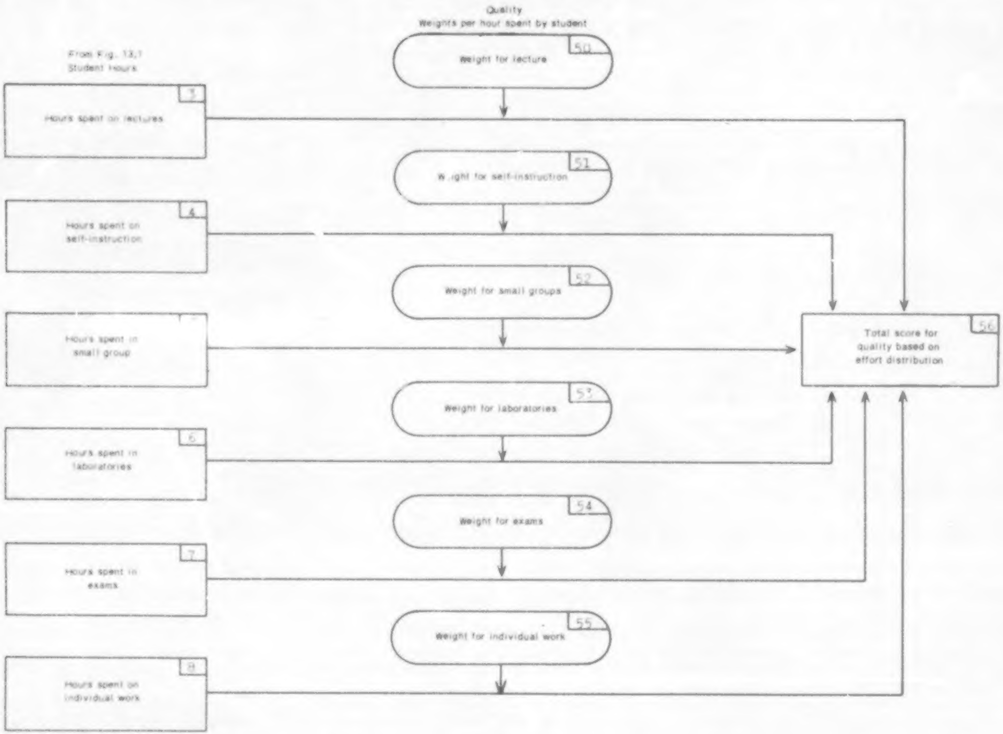
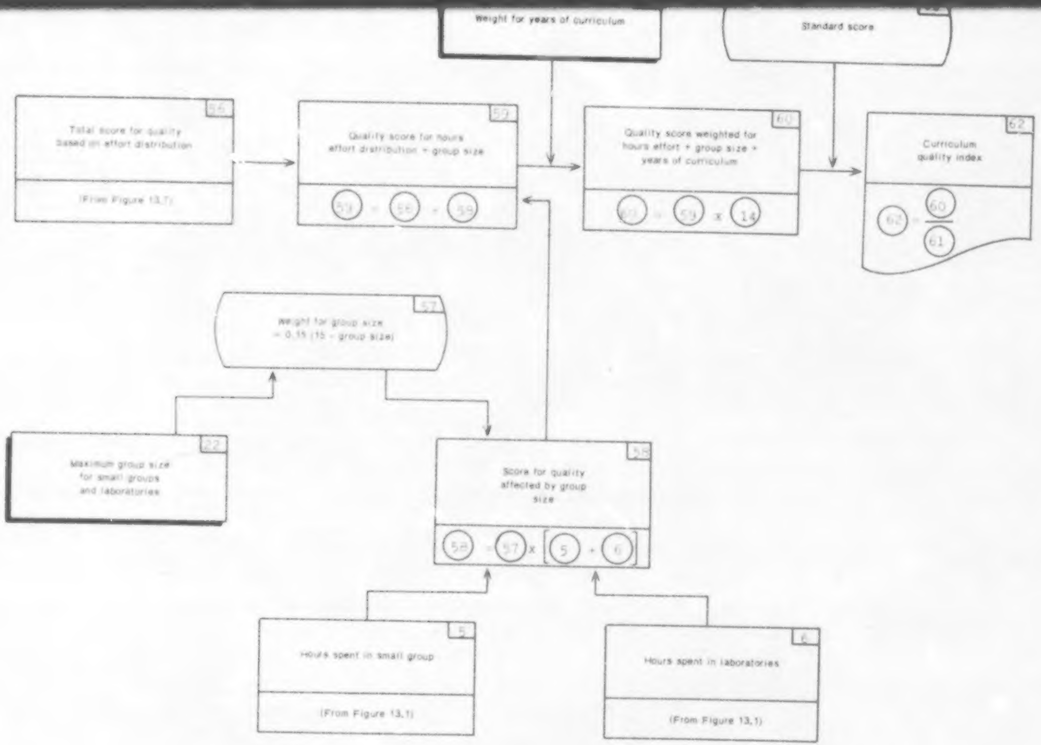
1) For game design constructions, see Bellman, Richard, et al; "On the Construction of a Multi-stage, Multi-Person Game", Operations Research, Vol.5, No.7, August 1952.

CALCULATION OF CURRICULUM QUALITY INDEX


Quality
Weights per hour spent by student
From Fig. 13,1
Student Hours
3
Hours spent on lectures
50
Weight for lecture
51
W .ight for self-instruction
4
Hours spent on self-instruction
52
Weight for small groups
Hours spent in small group
56
Total score for quality based on effort distribution
53
Weight for laboratories
6
Hours spent in laboratories
54
Weight for exams
7
Hours spent in exams
55
Weight for individual work
8
Hours spent on individual work

Note: (56) = [③ x (50)] + [④ x (51)] + [⑤ x (52)] + [⑥ x (53)] + [⑦ x (54)] + [⑧ x (55)]


Weight for years of curriculum
Standard score
56
Total score for quality based on effort distribution
(From Figure 13.7)
59
Quality score for hours effort distribution + group size
59 = 56 + 58
60
Quality score weighted for hours effort + group size + years of curriculum
60 = 59 x 14
62
Curriculum quality index
62 = 60 / 61
57
Weight for group size = 0.35 (15 - group size)
22
Maximum group size for small groups and laboratories
58
Score for quality affected by group size
58 = 57 x [5 + 6]
5
Hours spent in small group
(From Figure 13.1)
6
Hours spent in laboratories
(From Figure 13.1)

divided by a standard score (oval box 61) to give an index of curriculum quality (box 62).

This concludes the discussion on the basic logic of the USG model. It derives all the calculations that appear in the output, a sample of which appears in Figure 13.9. The output also lists some decision variables and intermediate output for purposes of record for the game player. References of each line in the output to the text is shown in Appendix B. Also, as an appendix is a problem and its numerical solution illustrating every step of the computations made in the USG and corresponding to the flow diagrams in this chapter, it is designed to elaborate and reinforce the discussion of the logic in this chapter.

The logic of the USG model does indicate an important limitation: the scope of the model is limited not only to just the academic sector but to the teaching resources therein. This restriction is relaxed in another gaming model: RRPM 1.6. It is the subject of our next section.

4. RRPM 1.6

4.1. Introduction

RRPM is a family of models developed by the National Center for Higher Education Management Systems in the U.S. During the development of the first operational version, there was a need felt for a model that could be used for training management in a gaming situation. In response to this need, CEM(1) (Cost Estimation Model) was developed. Then came the first operational version, RRPM 1.3 with its own gaming subset called RRPM 1.35. All these were superseded by RRPM 1.6 which is not only a gaming model but also one that is used for programmed planning and budgeting. In 1973 there were 127 institutional users of this model and the CEM(2).

In the gaming mode, RRPM 1.6 can be used for decision-making at the instructional departmental level or at higher institutional management levels. It calculates all resources required for the academic and the non-academic sectors. It is this second sector and the non-teaching resources in the academic sector that do not exist in USG and it is here that RRPM 1.6 can be used as an extension or continuation of USG. The USG is more relevant to the European context and hence should be used in Europe for the teaching sector. It could

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1) Colby, Springer, Cost Estimation Model, Boulder, Colorado: NCHEMS at WICHE.

2) NCHEMS: Directors Annual Report, 1973, p.13.

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UNIVERSITY OF UTRECHT BIOLOGY

                                              73-74

GENERAL DATA
SHORTAGE/SURPLUS T-HOURS (IN 100'S)        -207.60
STUDENT/STAFF RATIO                           25.00
STAFF/ASSISTENT RATIO                          3.00
CURRICULUM QUALITY                            90.65
SALARY COSTS (USD, IN 10000'S)                43.00
SAL-COSTS/STUDENTS (USD, IN 100'S)             8.60

CURRICULUM
STUDENTHOURS/YEAR (IN 100'S)                  16.00
PERCENTAGE LECTURES                           40.00
PERCENTAGE SELF INSTRUCTION                    3.00
PERCENTAGE SMALL GROUPS                       10.00
PERCENTAGE LABORATORY                         12.00
PERCENTAGE EXAMINATIONS                       20.00
PERCENTAGE INDIVIDUAL WORK                    15.00
CURRICULUM YEARS                               5.00

PERSONEL
STAFF IN TEACHING                             15.00
STUDENTASSISTENTS                              5.00
STAFF IN CURRICULUM DEVELOPEMENT               0.00
PERCENTAGE SPENT ON TEACHING                  40.00
PERCENTAGE SPENT ON RESEARCH                  30.00
PERCENTAGE SPENT ON OTHER ACTIVITIES          30.00

STUDENTS
NUMBER OF STUDENTS                           500.00
GROUPSIZE MAXIMUM                             10.00
NUMBER OF GROUPS                              50.00
```

then be extended to the rest of the institution by using RRPM 1.6. It is this extension that we are concerned with in this chapter. In it we will examine the logic of this extension and in a somewhat brief and summary manner (we are concerned only with what is necessary to play the extended part of RRPM 1.6). For the detailed logic and numerical examples of solution (of the extension and the earlier part of the model), the reader is referred to Clark et al.(1).

4.2. Partial Logic of RRPM 1.6

The partial logic of RRPM 1.6 to be discussed in this chapter is shown in Figures 13.10 and 13.11. We start with the salaries for the instructional staff (box 1 in Figure 13.10). This is calculated in the USG or in the earlier part of RRPM 1.6, though the approach is very different. In USG, one allocates the student's effort while in RRPM 1.6 one develops the teaching load by using an Induced Course Load Matrix (ICLM). This ICLM approach is also used by TUSS, the model used at the University of Utrecht, which also developed the USG.

In addition to teaching salaries, there are in every teaching cost center "other" salaries. These are for personnel like secretaries, student assistants doing non-teaching work and clerks. They need to be calculated for each cost center (in academic and non-academic sectors) and this is done either at the discipline or departmental level.

To calculate the non-teaching staff (box 4) we used a staffing relationship (box 2) and its relevant coefficients (box 3) which in the RRPM 1.6 are all decision-variables. The relationship is typically of the form:

$$Y = a + b_1 X_1 + b_2 X_2 + - - + b_n X_n$$

where Y = variable to be estimated
a = fixed coefficient
b's = variable coefficients
X's = the variables used for estimation purposes.

There is no practical limit to the numer of X's that are used. They could also be zeros, in which case Y is fixed and Y = a. Typically, there is at least one X. For example, the staff (in an academic department) is a function of the number of teaching staff (or faculty). This then becomes X_1. In the case of the RRPM 1.6 this value is calculated in previous computations and is known to the computer program (hence this is not shown in Figures 13.10 and 13.11). If, however, the variable were exogenous (external to the

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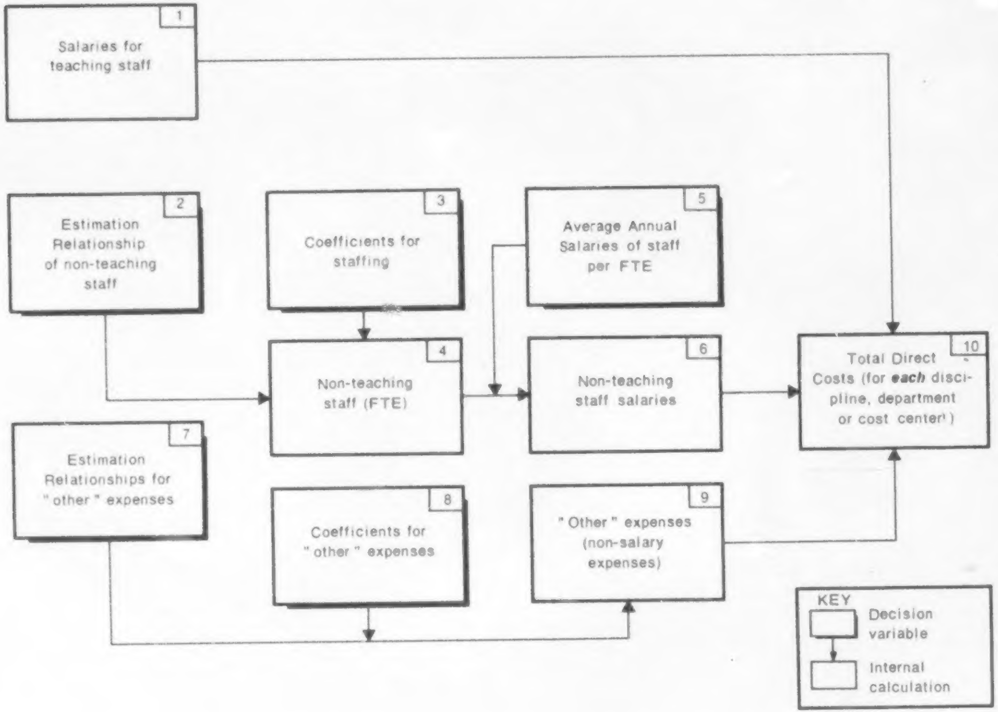
1) Clark et al., Introduction to the Resource Requirements Prediction Model 1.6. Technical Report No.34A. Boulder, Colorado: NCHEMS at WICHE, 1973.

Calculations for each Academic Discipline or Department or Cost Center


1
Salaries for teaching staff
2
Estimation Relationship of non-teaching staff
3
Coefficients for staffing
4
Non-teaching staff (FTE)
5
Average Annual Salaries of staff per FTE
6
Non-teaching staff salaries
7
Estimation Relationships for " other " expenses
8
Coefficients for " other " expenses
9
" Other " expenses (non-salary expenses)
10
Total Direct Costs (for each discipline, department or cost center)
KEY
Decision variable
Internal calculation

the number of letter enquiries received by the department, then this variable must be provided. In most cases this does not occur and hence it is also not shown in Figures 1; 10 and 13.11. But the functional relationship and the coefficients (fixed and variable if any) must be provided as decision-variables (boxes 2 and 3 respectively. This information enables the calculation of non-teaching staff (box 4) in FTE which when multiplied by the average annual salary of each staff (box 5) gives the non-teaching salaries (box 6) in the academic sector.

There may be more than one staff type each having a different average annual salary and a different estimation relationship and coefficients. In such a case, there must be a set of estimation relationship, coefficient and salary for each category of staff. Again this is not shown in Figure 13.10 for sake of simplicity.

Having calculated salaries, we need to calculate all other costs. These include supply, travel, communications, etc. This is a residual category to account for all non-salary costs that can be directly associated with the academic cost center. To estimate this cost component (box 9) we need an estimation relationship (box 7) and its coefficients (box 8). Again, as with staff costs, we may have more than one set if the categories are non-homogeneous for costing estimation purposes.

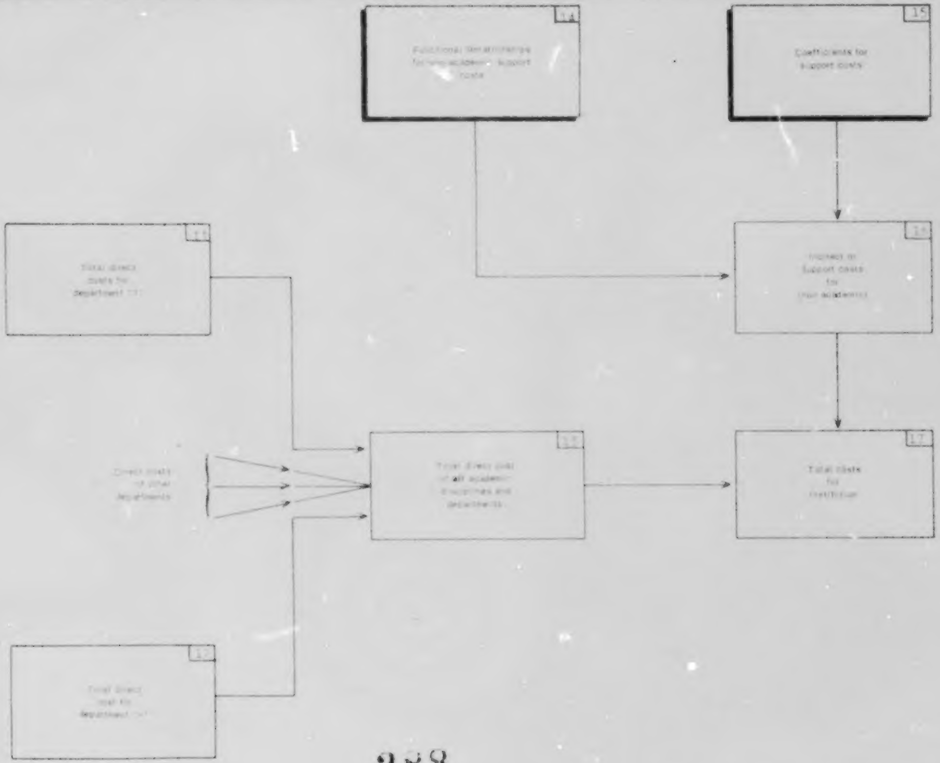
We now calculate the total direct costs for each cost center (box 10) by summing the teaching salaries (box 1), non-teaching salaries (box 6) and "other" expenses (box 9).

The calculation shown in Figure 13.10 is done for each of all the academic cost centers. All these calculations are shown as boxes 11 and 12 in Figure 13.11. They are aggregated (or summed) to give the total direct costs for all academic cost centers (box 13). What remains now is the non-academic costs, also known as "overhead" or "support costs" or "indirect" costs. This is calculated (box 16) with one functional relationship (box 14) and one set of coefficients (box 15). This cost when added to the total direct costs of all academic departments (box 13) gives the total institutional costs (box 17).

The functional relationships for non-academic support (box 14) and the "other" expenses (box 7) are similar conceptually to that used for staffing (box 2). Except, however, that in estimating support costs we specifically use more than one variable. Consider, for example, the supply cost used by a cost center of the department of chemistry. It may appear as follows:

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3$$

Where X_1 = No . of student contact hours in lecturing (in the Chemistry department).


14
Functional Distributions for non-academic support costs
15
Coefficients for support costs
11
Total direct costs for Department (1)
16
Indirect or Support costs for (non academic)
Direct costs of other departments
13
Total direct cost of all academic disciplines and departments
17
Total costs for Institution
12
Total direct cost for Department (n)

Chemistry department).

X_3 = No. of teaching staff (FTE) (in the Chemistry department).

Then the coefficients are as follows:

a = fixed cost (independent of student or staff or other variable)

b_1 = supply cost per student contact hour in lecture (in the Chemistry department).

b_2 = supply cost per student contact hour in laboratories (in the Chemistry department).

b_3 = supply cost per FTE teaching staff (in the Chemistry department).

This type of relationship is not confined to RRPM 1.6 or for that matter to educational models. They are used many times in everyday life. For example, it is used to calculate the taxi fare in most countries. When one engages a taxi, even without it moving an inch, the meter shows a cost - a fixed cost (coefficient a). To this is added the product of the kilometers travelled (X_1) and the cost per kilometer (coefficient b_1). Then, if there is a long wait, there is the product of the time waited (X_2) multiplied by the coefficient of cost per time unit waited (b_2). Also, if you have baggage, then there is an additional cost of the number of bags (X_3) multiplied by the cost per bag (call it the baggage coefficient b_3).

The relationship and the coefficients in our taxi example are determined by some bureaucrat responsible for such things and is programmed into the meter. Similarly, in the RRPM 1.6 model we need to state the relationship and coefficients. In the game version, this must be done by the team or players.

We need one relationship (or equation) and one set of coefficients for each support cost category and for each academic cost center. Note the large number of estimation equations for support costs for each academic cost center and yet only one estimation equation for all non-academic support. In the earlier version of RRPM (i.e. RRPM 1.3) there were more such non-academic support equations(1) but the users found them difficult to state(2) and somewhat more difficult to determine the different cost coefficients. Hence the aggregation in RRPM 1.6.

There are some logic relationships that have been deleted. For example, RRPM 1.6 considers the salaries of a department chairman for each academic cost center. This has been deleted because it is

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1) Hussain, K.M., A Resource Requirements Prediction Model (RRPM 1): Guide for the Project Manager. Boulder, Colorado: NCHEMS at WICHE, 1971, p.II.

2) See Hussain and Martin (1971) for experiences of pilot institutions that implemented RRPM 1.3.

not relevant to the playing of the game in the extended version. Also, in RRPM 1.6, the costs are allocated within each academic cost center to each course level. This enables calculating cost for each course level which when used with the ICLM, gives unit costs at each student level. A discussion of such costing will require a discussion of the ICLM, the credit hour concept, course levels and the curricula pattern which is quite different to the European environment. Therefore it is deleted. But again, the interested reader is referred to Clark et al., 1973.

There are, however, many unit costs which are calculated and will be mentioned. These are:

1. Cost per student credit hour in each discipline for each course level.
2. Cost per student contact hour in each discipline for each course level.
3. Cost per student in each academic program for each student level.

This constitutes a minimum discussion of the logic of the extension of RRPM 1.6 to the USG. Some logical differences between the USG and RRPM 1.6 may be of interest to the reader and so it is the topic of the next section.

5. COMPARISON OF GAMING MODELS

5.1. Purpose of Comparison

In this section, we will be concerned largely with the differences between USG and RRPM 1.6, though references will be made to other models as this becomes appropriate. Furthermore, in the case of RRPM 1.6, the comparison and evaluation will not be confined to the part of RRPM 1.6 that is the extension of USG but to the entire model. Finally, the comparison will be on the logic as well as considerations of implementing and running the model.

5.2. Evaluation of USG and RRPM 1.6

Of all the gaming models and their many versions, USG is by far the simplest both conceptually and operationally. To run USG, one can use a computer if available. The computer programs are written in a very simple set of the most common program language (FORTRAN) and require very little computer storage making them virtually usable on any computer. In case of a computer breakdown during the game, the game administrator need not lose a heart beat (as the author did in running RRPM 1.6) and can do the computations by using an adding machine or a slide rule. This is impossible in the case of bilities of running the COBOL language.

USG can be run either in the batch-mode or on a terminal. Its output is in either Dutch or English and will soon be also available in French. Thus it will cause few if any communication problems when run in Europe.

Even with its simplicity USG is able to convey the most important advantages of a simulation model. That is, the capability of generating answers to "what if" type questions: experimenting with different alternatives without having to pay possible adverse consequences of the decision; and finally forcing the players to analyze quantitative output and make trade-offs.

Because of the small demand on understanding the game and preparing the input, USG is very attractive as a first introduction to gaming in higher education. Within an hour, a newcomer to the game can start playing after being introduced to basic concepts of effort distribution, class sizes, teaching staff needs, and personnel ratios. Most important, and this is unique to USG, there is a quality index, albeit a controversial and debatable one, and also an output index, the maximizing of which provides a goal and an objective-oriented attitude in the game.

The outputs of USG can be displayed so that comparisons can be made. A team can make decisions for up to five years in the future and all the five year consequences can be displayed on one page. Alternatively, the decisions of up to five teams can be displayed for any one year. Such comparisons are not possible in RRPM 1.6 because there is a great deal of output for any one year. There is, however, the capability of comparing results of up to 9 different decisions in RRPM 1.35(1).

In balance of some of its advantages, USG has some limitations, including its heroic assumptions like the class size and ratio of instructional effort to student effort being independent of level of student. Also, the USG has a very limited scope. It considers only one academic unit. True the model can be run many times once for each academic unit. But even then there is a serious limitation. USG does not allow for any "crossing" between academic units. Students in one academic unit must take all their courses within that unit. In the university of Utrecht, where there are only five "faculteits", this is quite realistic. But there is a demand for more faculteits and academic majors with students taking courses in academic departments specializing in discipline areas. Thus a physicist may take

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1) Gulko, W.W. and K.M. Hussain, A Resource Requirements Prediction Model (RRPM-1) - An Introduction to the Model, Boulder, U.S.: NCHEMS at WICHE, 1971, p.33.

Maths in the Mathematics department rather than be limited to the teaching of mathematics in the Physics department. This freedom from the boundary rigidities of the traditional educational system can be seen in many new European universities. An example is the New Lisbon University that will start in 1976.

The freedom of taking courses in departments other than that of one's major in RRPM 1.6, enables its players to question the consequences of different curricula requirements or different student preferences on the load of each department. Also, the player can ask organizational type questions: What if we were to close the Engineering College? How would it affect the load in the department of Mathematics, English, etc? These questions can be asked in a game mode, but these are realistic questions facing many an administrator (or manager). The RRPM 1.6 answers such questions when used in the operational mode as a tool of planning and budgeting.

RRPM 1.6 generates the teaching resources as does USG, but in addition it projects the resources for non-teaching personnel (including administrative heads), as well as other support expenses. This is done for all academic units simultaneously, and then non-academic resources are calculated giving the total annual budget. This is the total operating budget, not the capital budget. RRPM 1.6 (like USG) is not concerned with space and building. The earlier version of RRPM 1.35 did space calculations(1).

RRPM 1.6 does introduce the concept of institutional support costs and allocation of such costs to academic programs giving unit costs per student in each academic program as well as costs for a unit of production (credit-hour or contact-hour).

The additional calculations in RRPM 1.6 has a price that must be paid. The player has to invest more time in learning about the logic of the model and there are many input sheets that must be completed. But for someone using RRPM 1.6 in the operational mode, there is little incremental cost of learning to play the game. The benefits resulting from becoming acquainted with the mechanics and logic of the game are well worth his effort. Besides the game provides insights into the interrelationship of variables and the process of decision-making that is valuable for anyone who has planning and budgeting responsibilities.

A summary of the above discussion is presented in a tabular form for easy reference. This is done in Figure 13.12.

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1) See Hussain, K.M., (1971), p.12.

Figure 15.12

COMPARISON OF USG AND RRPM 1.6

	USG	RRPM
Calculation	Can be hand calculated + use of computer	Requires computer
Computer mode	. Batch . Terminal	. Batch
Computer related needs	. FORTRAN	COBOL
Use	For gaming	For gaming + planning and budgeting
Scope		
. academic unit	One at a time	All at once
. sector covered	Instruction only	Instruction + support
. resources included	Teaching staff	Teaching staff + other staff + other support expenses
Output	Teaching staff surplus or shortage (in hours)	Teaching staff needs (in FTE)
		"Other" Resource needs
	Teaching Salary Cost/student	Total Cost (Direct + Support) for . student . program . Credit-Hour . Contact-Hour
	Quality Index	

5.3. Scope of the Gaming Models

The scope of the model such as USG or RRPM 1.6 is a problem often debated amongst game designers. Thomas and Deemer(1) have the following view:

> When as in operational gaming, the increased difficulty of solution easily escapes notice, the temptation to enlarge the model becomes all the greater ... But this temptation to elaborate should be the more strongly resisted in gaming. For to yield is to court delusion. Not only is there the doubly diminished effectiveness of solution mentioned before as a consequence of

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1) Thomas, C.J., and W.L. Deemer, Jr., "The Role of Operational Gaming in Operations Research", Operations Research, Vol.5, No.1, February 1957.

> excessive elaboration, but there is also another difficulty that arises in interpreting the results of gaming. One tends to forget that the game is not reality itself. The 'appearance of reality' so useful in teaching becomes dangerous in application.

In the above context, neither USG nor RRPM 1.6 are "dangerous" especially in Europe where the environment in each country is different and this is recognized. As for enlarging the model(1), USG certainly cannot be criticized. RRPM 1.6, however, is an expanded model since it was primarily designed for operational use but this expansion can be reduced by changing decision variables into parameters for the game. Simplifying the model has other advantages: that of explaining and starting the game, of computation of results, of administrating its play, and finally, of easing and speeding the decision-making during the game.

Neither USG nor RRPM 1.6 are strictly competitive games. In the case of the USG, the administrator of the game may decide to state one objective for all the teams, such as maximize the curriculum quality index. Now if all teams are given the same starting values of parameters and the same environment in the problem, then the game becomes competitive. But the game is not competitive (and neither game is) in the sense that the effect of the strategy of one team affects the result of the other team's strategy. Thus it is not a zero-sum game. It is a non-zero sum game because the loss of one team is not the gain of another team. They do not share the student enrollment population; they do not share the available funds; nor do they share the instructional staff availability. The game is fully deterministic with known parameters and known relationships. The game is not probabilistic nor is it stochastic. The teams are playing against "nature" which is typically neither benign nor benevolent. However, for pedagogical reasons, the game administrator may during the game change some parameters or even fix some decision variables. For example, he may announce that there is an unexpected change in the availability of funds for higher education and so all instructional staff will be increased by 20 per cent (or decreased by 20 per cent). Then "nature" is no longer neutral. Also, the game administrator may fix the share of a team (of students, staff or funds) based

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1) An extreme example of a complex game with a large number of variables is the Carnegie Tech. Game. It has 300 decisions each period and nearly 2,000 items of information to analyze after each decision. It is, however, designed for experience in competition, negotiation, organization and reflection. For details, see Cohen, H.J. et al. The Carnegie Tech. Management Game: An Experiment in Business Education. Homewood, Illinois: Richard D. Irwin, Inc. 1964.

the game could approach a zero-sum game but it is not structurally designed that way as are some business games(1).

5.4. Simulation models and Gaming models

One final topic: that of the difference between a game and a simulation model. We have made many references to RRPM 1.6 as being a game as well as an operational model used in decision making for budgeting and long range planning. In contrast USG is strictly a game. What then is the difference between a simulation model and a game?

Klaproth(2) makes the following distinction:

> "While a management game used in a decision-making laboratory is a form of simulation, it is somewhat different from the type of simulation one would utilize to aid in the process of making an actual business decision. In the real problem context, one would have developed a simulation model specific to the particular organisation with parameters inserted to reflect the actual expected performance of the process within the organisation. The decision-maker would 'try-out' various choices and observe the results (he may also vary the parameters in an effort to determine what effect changing conditions might have on his various choices). Ultimately he would choose that decision which gave results most closely reflecting his objectives.
> In the game situation, the participant is presented with a situation and told to make a set of decisions. This set of decisions is final, and while the participant can see the results of his set of decisions, he has no opportunity to 'try again' under the same situation. This difference between the gaming situation and the actual utilization of simulation to aid in the decision-making process is due to the totally different objectives of the two approaches. The game utilized in the decision-making laboratory needs only to represent reality to the extent that realistic results are obtained from the decisions put into it. The performance required of a specific simulation model used to assist in a decision process is much more exact".

There are other differences. Games can be competitive, with malevolent opponents, unlike a simulation model where one plays against "nature", which is benevolent. Also, games sometimes include elements of negotiation and bargaining as in the WARP Industries game developed in Sweden. The game, however, is typically more abstract from reality and there is more interaction between the human player and the abstraction.

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1) A good example is the AMA game. For details see Ricciardi et al., (1957).

2) Klaproth, W.W., pp. 7-8 (1971).

times the separate design of simulation models and gaming models. And for a model that performs both functions (like the RRPM 1.6) there must be compromises in design. This task was simplified in the case of RRPM 1.6 because it is not a competitive model and it was intended to be simple in its structure even as a simulation model. It is thus much less complex and therefore much less close to the real life situation than is CAMPUS, the next most commonly used model in the U.S. It is also less conceptually complex in its academic sector than the European models HIS and TUSS though it has a larger scope in that it includes the non-academic structure, non-teaching instructional costs and unit costs. Also RRPM 1.6 had the advantage of evolving from two other models, RRPM 1.3 and CEM. RRPM 1.3 was primarily a simulation model while CEM was primarily a game. In the extensive use of the CEM game, the designers learned much about modelling. Thus the game was used as a modelling technique. This use of a game will be developed further along with a discussion of other uses and limitations of games. This is the topic of our next and final section.

6. USES AND LIMITATIONS OF GAMES

There are at least three major uses of gaming: education on a model; training in decision making: and finally, gaming as a research tool. These uses are not always mutually exclusive, and hence their discussion will be somewhat collective. Following this, we shall discuss briefly some limitations of games.

6.1. Uses of Games

There is learning and discovery that often emerges from a game in spite of its artificialness and inconclusiveness. Goodman(1) describes this as follows:

> "Games .. involve an experience which is dramatic without being decisive. The players in addition to having freedom to discover ends not predetermined, also have the freedom which comes from the tentativeness of the gaming situation. Although the game is exciting, involving, engaging even, it is never 'for real'. Similar to the traditional conception of the essay, games, too, are tentative attempts which pretend neither to absolute truth nor to final outcomes. They are, rather, an exploration, and

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1) Goodman, F.L., "An Introduction to virtues of gaming" in Tansey, P.J., (ed.), Educational Aspects of Simulation, 1971. London: McGraw-Hill, 1971, pp. 28, 30, 36-37.

> in the long run..... In games ... winning has more to do with successful learning than with any score-keeping principle. It is as if every engaged player wins, perhaps not blue chips or a new contract, but some further insight, some glimpses, however tentative, of further discovery...What an individual discovers of a given choice within the rule framework is, however, more directly a function of his own skill and that of his competitors than a function of what his coach has said and done. Each rule he has received through the coach is something to be tested and evaluated (even a formal game rule); it is not to be accepted as an ultimate simply because the coach favours it, or even insists on it...He (the player) 'experiments' with the environment to 'discover' the rule for himself...he *acquires* an education through a process of *discovering* himself".

The gaming model is an abstraction of real life but this has its advantages. As Worth David(1) points out:

> ...it enables the trainee (player of game) to assume a top level administrative role without forcing real people to suffer the consequences of a serious error in judgement. Free to experiment, to act without pressure to meet an immediate crisis with an adequate but inefficient solution, the trainee can concentrate on learning techniques of rational decision making. Furthermore, this freedom allows the trainee...to apply the criterion of efficiency to the broader purposes of the organisation...Finally, as advocates of business simulations have pointed out, the abstraction of the model provides a powerful diagnostic tool(2). Concentrating as it does on the essential elements of the process, it may bring previously unrecognised problems and relationships to the attention of the instructor as well as the trainee.

Gaming is often useful in the identification of the information needed for decision-making; extracting that information and then synthesizing and analyzing the available information. Two studies done by Dill and his associates(3) show that players improved in

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1) David, J. Worth, "*Simulation in the Preparation of Educational Administrators*". The parenthesis has been provided by the author.

2) Kukric, Z., "Training Managers through Decision-Making in Simulation" in *Simulation and Gaming. A Symposium*, Management Report, No.55, New York: American Management Association, 1961, pp.60-64.

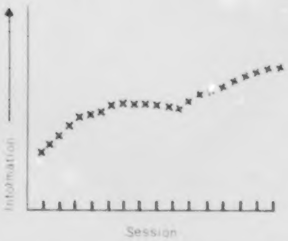
3) Dill, W.R. et al., "Strategies for Self-Education". *Harvard Business Review*, Nov.-Dec., 1965, pp.30-46, and William R. Dill and Neil Doppett, "The Acquisition of Experience in a Complex Management Game". *Management Science*. Vol.10, No.1, October 1963.

their ability to analyze and use data as the game progressed. One may question the transferability of this knowledge of information utilization (and principles of decision-making techniques learned in games) to the real world(1). But this is possible, given that there is some realism in the game model (as is true of USG and certainly true of RRPM 1.6) and a willingness and open-mindedness on the part of the player. There is some evidence that such a player can be taught to make rational decisions through gaming.

The information needed for analysis and decision is distinct from two other types of information: one, the information needed for playing the games (the mechanics and rules of play); and two, the information (or knowledge) acquired during the game on modelling, strategies and decision-making. These two types of information were the subject of research by the psychologist Neil Rackham. His results are displayed(2) in Figure 13.13.

Figure 13.13

INFORMATION CURVE



The information acquisition on the early sessions concerns the rules and mechanics of the game. This soon flattens out. Then it rises again and here the information acquired is the learning on modelling and decision-making. This kink in the curve will shift as the game becomes complex (to the right) or simple (to the left).

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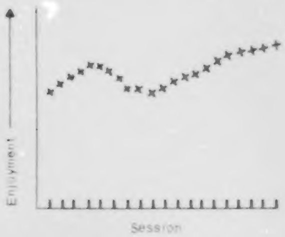
1) For a discussion of this subject, see Steele, J.D., "How valuable is Simulation as a Teaching Tool?" in Simulation and Gaming: A Symposium, Management Report No.55, New York: American Management Association, 1961, pp.27-37.

2) Rackham, N., "The Effectiveness of Gaming Simulation Techniques" in R. Armstrong and J.L. Taylor (Eds.), Instructional Simulation Systems in Higher Education, Cambridge: Cambridge Institute of Education, 1970, p.207.

ment(1) as it varies with the number of sessions played. This is shown(2) in Figure 13.14.

Figure 13.14

ENJOYMENT CURVE



The enjoyment curve has a distinct "trough". The enjoyment drops after the initial novelty and excitement wears off. Then, however, it increases as the player applies his knowledge and tries out new strategies.

The trough of perceived enjoyment shifts (to the right like the information curve) with the complexity of the game. In most cases though, the trough corresponds to the flat (or low) part of the information curve. This means that at times of the game, both curves are simultaneously low. This could partly be compensated by changes in the complexity of the game and is a point when the game administrator must be most alert.

Gaming is also used to learn about modelling. Kossack(3) observes:

> "Within this admittedly artificial environment, games give participants an opportunity to compare their decision-making assumptions with those of the game model, to discuss and evaluate both and compare them critically. In other words, the game serves as a sort of catalyst to critical self-analysis and introspection."

Such analysis and introspection could lead to contemplation of the meaning of the function and relationships; their need and significance; any ambiguities and their clarifications; the contradictions and their being resolved.

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1) The perceived enjoyment was determined on an ordinal scale using questionnaires both during and after the game.

2) Rackham, N., ibid.

3) In Simulation and Gaming; A Symposium, Management Report No.55, New York: American Management Association, 1961.

Gaming can also be used for research on group-decision-making. In real life, decisions in budgeting and planning are collective group decisions. These can be simulated in a game for different types of groups.

One variable is the size of the group - or the team in the case of the game. As this increases, the cross currents increase more than linearly, and the group-dynamics become more complex. Decisions take longer and are more difficult. But what are the relationships involved and what is the optimal or near-optimal size?

Another variable is the composition of the group. How would the decision of all administrators differ from that of all scientists, or all professors or all business managers? And why? What is the best mix not only in terms of functional background but also in terms of experience and knowledge in quantitative methods? And even emotional make-up and age?

Yet another variable is the organization of the team. One may ask how the decision varies with different organizational patterns. One possibility is for the game administrator to appoint a "rector" or "chancellor" for each team. Another would be to make each team elect its own head. The third alternative would be to let the team evolve its own organizational structure (or a lack of one) as it makes its decisions.

Another strategy would be to have an "observer" in each team who would then share his observations during the game evaluation. Making him an observer (previously announced or planted) does give him an emotionally objective view and could add to the evaluation.

Each of these alternatives and yet others can be simulated individually or collectively with other alternatives of team size and composition. Even if they were not used for testing research hypotheses they would be a valuable experience for players in group decision-making.

6.2. Limitations of Games

A game model is only as good as the perception of its designer. This perception is not only of the objectives of the game (and needs of the players) but also of the realism of the environment necessary to meet the objectives. The realism must of course be balanced with simplicity. But even with the best balance there are many situations excluded from the game, including those of high risk and high payoff. But these are precisely the situations that many a player would wish to explore since he cannot do so in real life. As a consequence of this inability, the player is frustrated and dissatisfied with the game.

The game has a psychological limitation in that it is never considered as "real". But experience with games has shown that once adjust to the constrained environment and if the game problem is made sufficiently difficult (and progressively more difficult with each play) then the players find the game not only meaningful but even enjoyable and sometimes even exciting.

The limitations of gaming is sometimes related to the way it is administered. This involves many decisions like the selection of players, the size, composition and organization of the teams, the time allowed for each play, and even the number of plays allowed. This last factor is important in long range planning games where it is necessary to have many plays to see and learn from the consequence of earlier decisions. The factor is important even in the USG where the investment of faculty in curriculum development has a delayed effect on the curriculum quality index(1).

The number of plays allowed also has an effect on perceived enjoyment and information acquisition as discussed in Figures 13.13 and 13.14. These curves show that the highest perceived enjoyment and highest information acquisition takes place only after a number of plays. This suggests that this point of maximum enjoyment and learning will never occur if the game is not played long enough. How long will depend on the complexity of the game and the responses of participants.

The use of the game is greatly limited if the players are not carefully oriented about the game model and the rules of the game. This must be done before the starting of the game. Once the game starts, the game administrator must be responsive to the needs of the players and alert to opportunities where learning can be initiated or reinforced.

In summary, it must be recognised that there are some limitations to games but these are outweighed by the advantages and values of games. This is reflected in the fact that games are used in most Schools of Business in the U.S. In some cases they are an entire course required of students in management. Such a requirement may never be made of educational would-be managers but certain games should be made accessible to them as well as to current educational managers. It is to facilitate that process that this manuscript is written.

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1) This relationship is not included in the discussion of USG in Section 3 because it was considered a "detail" and not part of the basic logic of the model.

ANNOTATED BIBLIOGRAPHY

This bibliography is concerned with survey type material on gaming and related topics. The citations in the text will not be repeated unless the titles are not fully expressive of their content or the citation was too specific.

This bibliography also excludes references to RRPM 1.6 which appear in a special annotated set of references in the Appendix.

Greenlaw, Paul S., Lowell. W. Herron and Richard H. Rawdon. *Business Simulation in Industrial and University Education*, Englewood Cliffs, N.J. : Prentice-Hall Inc., 1962.

Though written for business games this book has much that is relevant to games for university management, especially the chapters on the mechanics, logistics and organization of games. It also has an annotated list of many functional games.

Tansey, P.J. (ed.) *Educational Aspects of Simulation*, London: McGraw-Hill, 1971

This is a set of articles on simulation and gaming as used not only in teaching and in educational institutions but also in war games and international relations. It provides many insights in the educational and training values of gaming and simulation. Also included is a listing of games and simulations used in both the U.S. and Europe.

Thomas, C.J. and W.L. Deemer Jr. "The Role of Operational Gaming" in *Operations Research*, Vol.5, No.1, February 1957.

This is a survey of gaming. It is "old" but still very valid. Even though it appears in a mathematically oriented journal, it does not require any mathematical prerequisites for its understanding. It is highly recommended for the serious reader.

INTRODUCTION

To enable an interested party to run either USG or RRPM 1.6 - one needs a set of technical material. This is the content of these appendices. With the help of the appendices one should be able to comprehend and run both USG and RRPM 1.6. To use these models in a game context, there are two companion manuals, one for USG and one for the extension of USG using RRPM 1.6. These two companion manuals appear as appendices II and III. Both these manuals have almost the same content: the parameters and decision variables in the model; the output and input with samples; strategies of the game; comparison of USG and RRPM 1.6 (in the RRPM 1.6 Manual only); and a glossary of terms.

On RRPM 1.6, there is much documentation, both conceptual and technical. In fact, there is so much that there is perhaps a need for a guide through its literature. This is done in Appendix A.

For USG the logic is illustrated by a simple numerical example. This is done in Appendix B.

There is very little available in English on the systems documentation of USG. The one flow chart available is given in Appendix C. A program listing of USG appears in Appendix D.

To actually run RRPM 1.6 or USG in a game mode, it is necessary to have manuals for the users. These are shown as Appendices II and III respectively.

Summarizing, we have the following six appendices:

A. Guide to Documentation on RRPM 1.6.
B. Numerical Solution to USG.
C. Systems Documentation of USG.
D. Program Listing of USG.

To be found at the back of the book.

II. Manual for Using USG.
III. Manual for Using RRPM 1.6.

Appendix A

GUIDE TO DOCUMENTATION ON RRPM 1.6

No documentation on RRPM 1.6 is included in this appendix because it is already published and easily available elsewhere. What is perhaps needed is a guide to this literature. This is the purpose of this appendix.

An excellent description of the model and its logic expressed in flow diagram is Introduction to the Resource Requirements Prediction Model 1.6, by Clark et al., 1973, NCHEMS Technical Report 34A. Also included are a set of numerical examples of each type of computation. There are no mathematical prerequisites for reading this manual. A desire to learn is all that is required.

Anyone wishing to run RRPM 1.6 should get its System Documentation: Resource Requirements Prediction Model 1.6 System Documentation by Collard W.J., and M.J. Haight, 1973: NCHEMS Technical Report No.38. This includes a systems narrative and flow; the program documentation and flow; input specifications and sample input forms; record design forms; system messages and, finally, a brief chapter on systems modification necessary for implementing on different other computer equipment.

Supporting the systems documentation is a computer program listing in Resource Requirements Prediction Model 1.6 Program Listings 1973, NCHEMS Technical Report 39. This is a 303 page set of listings of all the programs and sub-programs needed to run RRPM 1.6. It does not include the JCL listings which will vary from computer to computer.

This document includes a set of demonstration data. This data produces a set of output reports. These are provided for checking and reference in Resource Requirements Prediction Model 1.6 Reports, 1973, NCHEMS Technical Report 34B.

For those who wish to implement RRPM 1.6 as a planning and budgeting technique (rather than use it as a game only), there is "A Blueprint for RRPM 1.6 Application" by Huff, R.A. and M.E. Young, 1973. It includes a set of diagrams appropriate for use as visuals.

For technical considerations of implementing RRPM, but RRPM 1.3 in particular, see Hussain, K.M., A Resource Requirement Prediction Model (RRPM-1) : Guide for the Project Manager, 1971, NCHEMS Technical Report No.20. For the experiences of pilot institutions in implementing

Prediction Model (RRPM-1) - Report on the Pilot Studies, 1971, NCHEMS Technical Report No.21.

RRPM is just one component of a set of institutional planning models. For an implementation of RRPM 1.6 as part of a set of other planning models, see Huff, R., et al., Implementation of NCHEMS Planning and Management Tools at California State University, Fullerton, 1972.

All the citations in this appendix are publications of NCHEMS at WICHE - the National Center of Higher Education Management Systems at WICHE. These publications can be acquired (if still in print) for a nominal production cost from NCHEMS at WICHE, P.O. Box P, Boulder, Colorado, U.S.A. 80302. Also available at production cost is a copy of the RRPM program (RRPM 1.3 or 1.6) on magnetic tape.

Appendix B

NUMERICAL SOLUTION FOR USG

This appendix is designed to supplement the text discussion of the logic of USG. A simple set of environmental conditions will be used to calculate all the output generated by USG.

The format will be graphic rather than textual. The flow diagram in the text will be used so as to provide reinforcement to the text.

For clarity and reference, the calculations will be followed by a list of decision variables and parameters. In each case, there will be a reference for each item to the diagrams in the text.

Problem:

Consider the following environmental conditions:

Ratio of hours spent by instructional staff for each hour spent by student in

lectures = 2
self-instruction = 1.5
small groups = 1.6
laboratories = 1.33
exams = 0.02
individual work = 0.01

Total effort of each instructional staff for 1 academic year (average) = 2,000 hours

Average annual salary of teaching staff and staff for curriculum development = $26,000

Average annual salary of student assistants = $8,000

The departmental staff had a meeting and decided on the following:

Maximum group size = 10
Curriculum period = 5 years

The staff availability was projected in FTE as follows:

teaching = 15
curriculum development = 0
student assistants = 5

Percentage time spent by average instructional staff member

on teaching = 0.4

on research = 0.3

on other activities = 0.3

The institutional management had a policy planning meeting and discussed institutional objectives. They discussed instructional quality and determined the following weights for each hour spent by a student in the different activities:

lecture = 1

self-instruction = 6

small groups = 4

laboratories = 4

exams = 1

individual work = 4

This top management group also reviewed decisions by the departmental group and after asking for some justification from this group, fully approved their decisions (as listed above).

The Office of Planning was asked to project the student enrollment for the "faculteit" under consideration. After much discussion and computations they projected an annual enrollment of students for the planning year at all levels = 500.

The Office of Institutional Research was asked for data on student effort spent and distribution of effort. They used historical data and made a survey of student attitudes. Their projections for the planning period were as follows:

Average hours spent by each student per year = 1,600

Distribution of student effort (in percentages) are

lectures = 0.40

special instruction = 0.03

small groups = 0.10

laboratories = 0.12

exams = 0.20

individual work = 0.15

Note on problem statement

The order of values given above follow fairly closely to the order in which they are listed as decision variables or parameters (Figures B3 and B4). In reality, the data is not so easily available and must be either calculated, researched or negotiated. Furthermore, many groups are typically involved. Some of this flavour is attempted in the problem definition above. Of course, it is oversimplified.

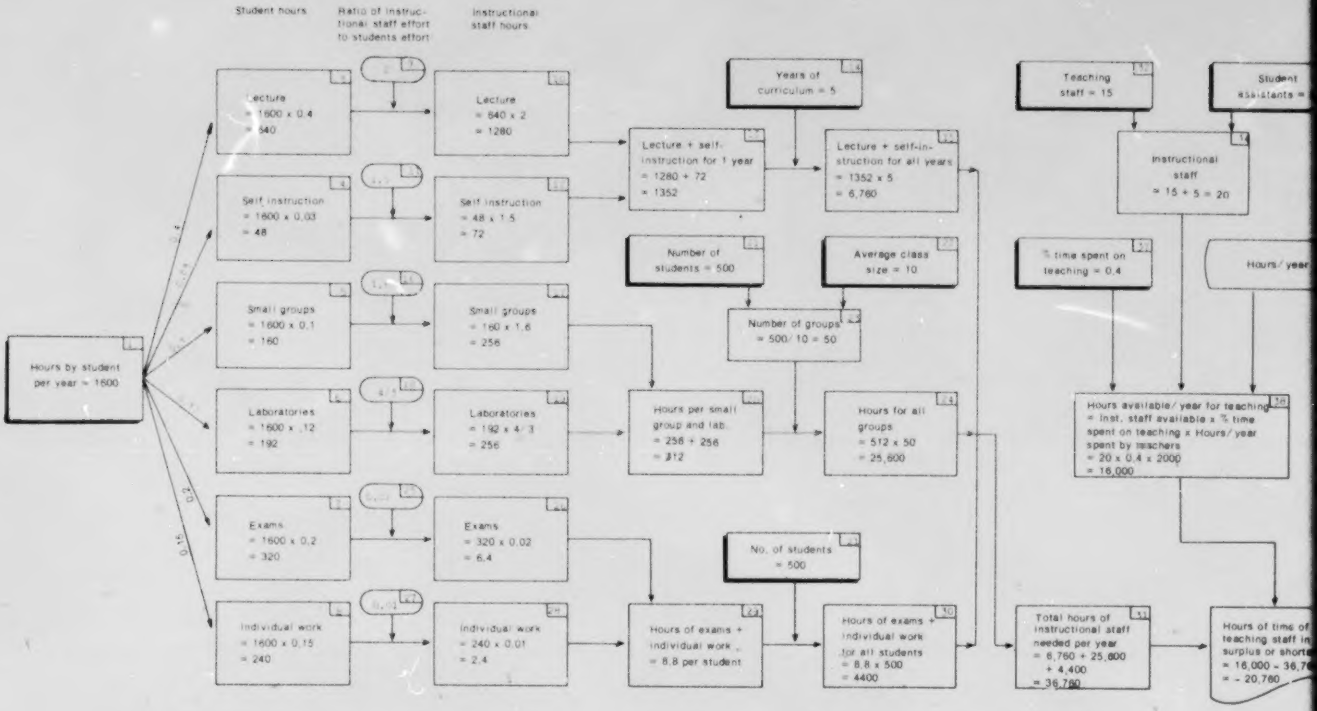
Given the above data, you are required to calculate the following:

1. Shortage or surplus of instructional staff hours
2. Student staff ratio (where staff is for teaching and curriculum development)
3. Teaching staff and student assistant ratio
4. Total salary costs
5. Salary costs per student.

The numerical solution is shown in Figures B1, B2 and B3. They can be compared to the solution by the computer program which appears in Figure B4. Note that the values appearing in both cases have the same values. Only some of the input is shown in the computer report for purposes of checking and reference. These inputs are referred to in the lists of decision variables (Figure B5) and to the computer output (Figure B4). Some values in the output are derived. An example is the percentage of research. The percentage of research and teaching is to be taken as 70 per cent and given that teaching is 40 per cent then the research becomes 30 per cent (S in Figure B4) and other activities becomes 30 per cent (T). Also, the number of groups (W) is derived data calculated by dividing the number of students (U) by the maximum group size (V). These references of output in Figure B4 and the text are shown in a table in Figure B7.

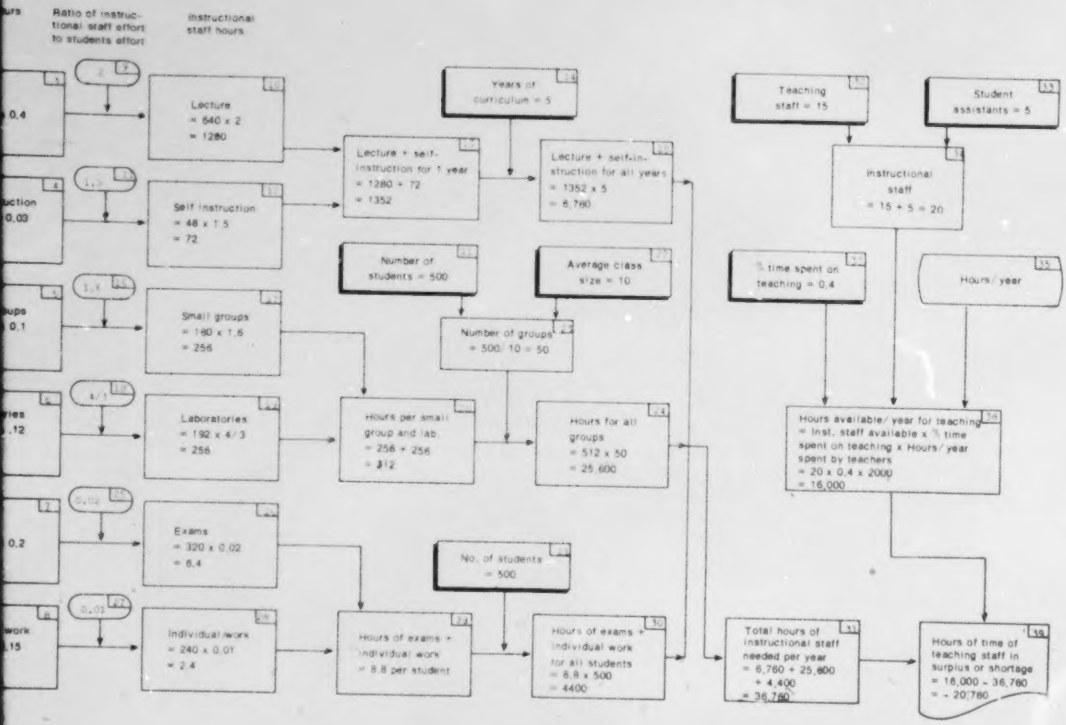
NUMERICAL SOLUTION TO PROBLEM ON USG

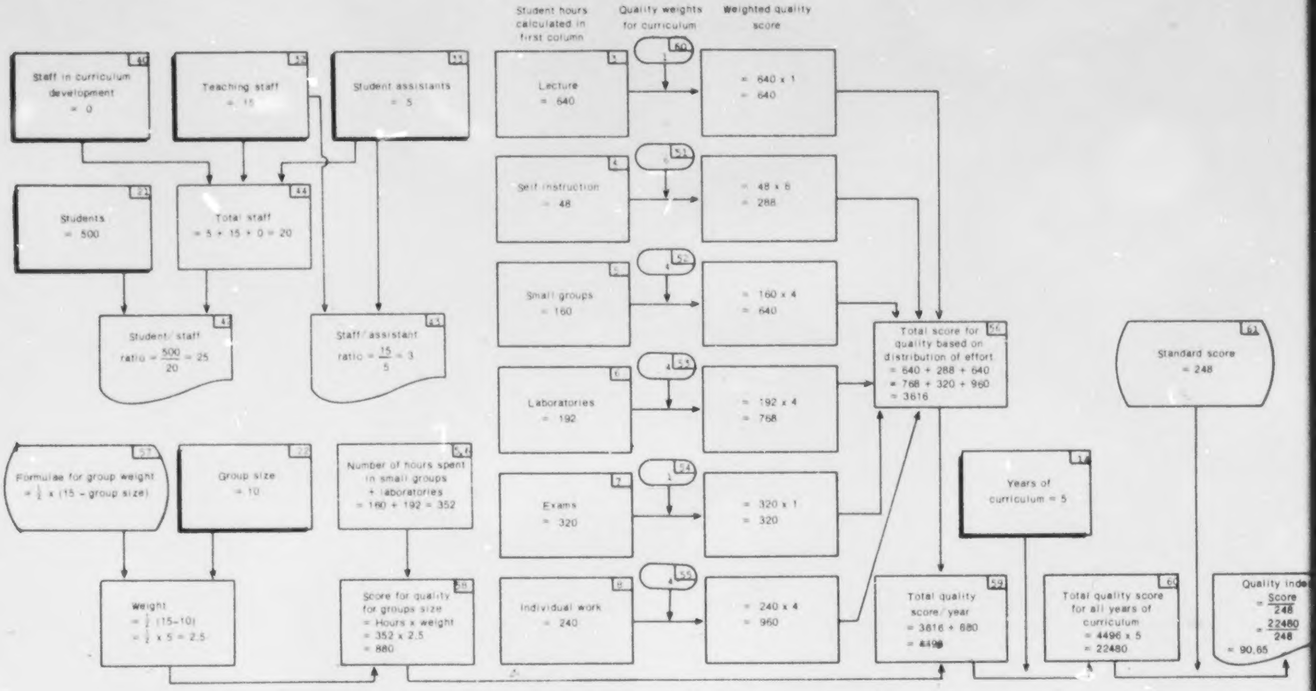
(Page 1 of 3)

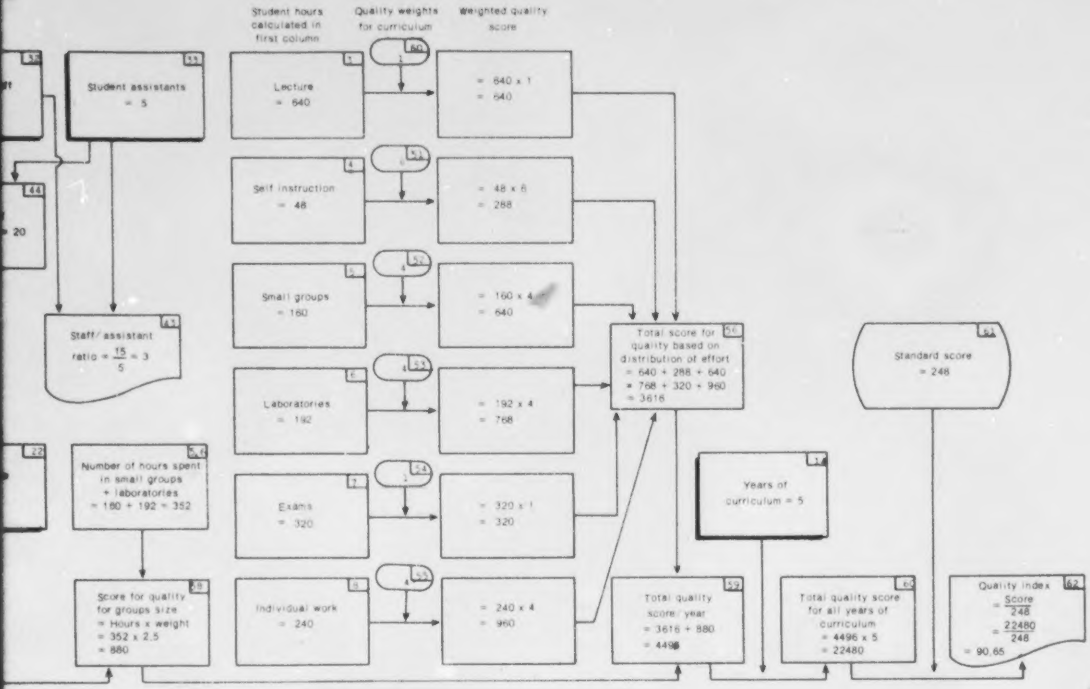

Student hours
Ratio of instructional staff effort to students effort
Instructional staff hours
Hours by student per year = 1600
0.4
0.03
0.1
0.12
0.2
0.15
Lecture = 1600 x 0.4 = 640
Self instruction = 1600 x 0.03 = 48
Small groups = 1600 x 0.1 = 160
Laboratories = 1600 x .12 = 192
Exams = 1600 x 0.2 = 320
Individual work = 1600 x 0.15 = 240
2
1,5
1,6
4/3
0,02
0,01
Lecture = 640 x 2 = 1280
Self instruction = 48 x 1.5 = 72
Small groups = 160 x 1.6 = 256
Laboratories = 192 x 4/3 = 256
Exams = 320 x 0.02 = 6.4
Individual work = 240 x 0.01 = 2.4
Lecture + self-instruction for 1 year = 1280 + 72 = 1352
Years of curriculum = 5
Lecture + self-instruction for all years = 1352 x 5 = 6,760
Number of students = 500
Average class size = 10
Number of groups = 500/10 = 50
Hours per small group and lab. = 256 + 256 = 512
Hours for all groups = 512 x 50 = 25,600
No. of students = 500
Hours of exams + individual work = 8.8 per student
Hours of exams + individual work for all students = 8.8 x 500 = 4400
Teaching staff = 15
Student assistants =
Instructional staff = 15 + 5 = 20
% time spent on teaching = 0.4
Hours/year
Hours available/year for teaching = Inst. staff available x % time spent on teaching x Hours/year spent by teachers = 20 x 0.4 x 2000 = 16,000
Total hours of instructional staff needed per year = 6,760 + 25,600 + 4,400 = 36,760
Hours of time of teaching staff in surplus or short = 16,000 - 36,7 = - 20,760

NUMERICAL SOLUTION TO PROBLEM ON USG

(Page 1 of 3)

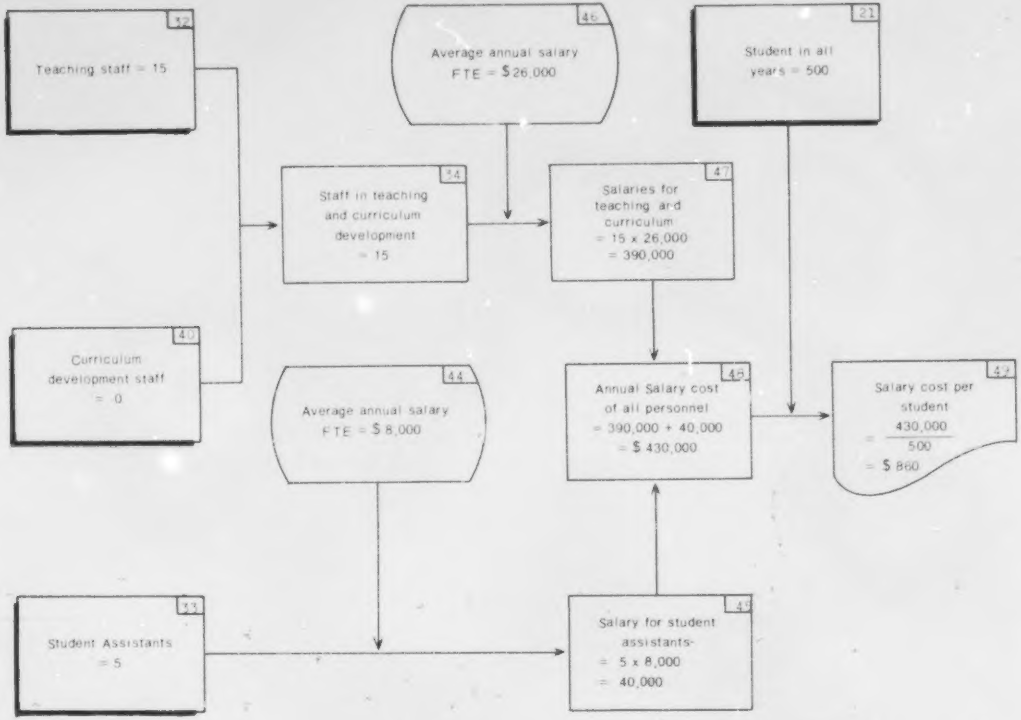

urs
Ratio of instructional staff effort to students effort
Instructional staff hours
3
0,4
4
uction
0.03
5
ups
0.1
6
ies
.12
7
0.2
8
work
.15
2
9
1.5
13
1.6
15
4/3
19
0.02
25
0.01
27
10
Lecture = 640 x 2 = 1280
11
Self instruction = 48 x 1.5 = 72
17
Small groups = 160 x 1.6 = 256
Laboratories = 192 x 4/3 = 256
Exams = 320 x 0.02 = 6.4
Individual work = 240 x 0.01 = 2.4
Lecture + self-instruction for 1 year = 1280 + 72 = 1352
14
Years of curriculum = 5
Lecture + self-instruction for all years = 1352 x 5 = 6,760
Number of students = 500
Average class size = 10
Number of groups = 500/10 = 50
Hours per small group and lab = 256 + 256 = 512
24
Hours for all groups = 512 x 50 = 25,600
Hours of exams + individual work = 8.8 per student
No. of students = 500
30
Hours of exams + individual work for all students = 8.8 x 500 = 4400
31
Total hours of instructional staff needed per year = 6,760 + 25,600 + 4,400 = 36,760
32
Teaching staff = 15
33
Student assistants = 5
34
Instructional staff = 15 + 5 = 20
% time spent on teaching = 0.4
35
Hours/year
36
Hours available/year for teaching = Inst. staff available x % time spent on teaching x Hours/year spent by teachers = 20 x 0.4 x 2000 = 16,000
39
Hours of time of teaching staff in surplus or shortage = 16,000 - 36,760 = - 20,760


Student hours calculated in first column
Quality weights for curriculum
Weighted quality score
40
Staff in curriculum development = 0
32
Teaching staff = 15
33
Student assistants = 5
3
Lecture = 640
50
1
= 640 x 1 = 640
21
Students = 500
44
Total staff = 5 + 15 + 0 = 20
4
Self instruction = 48
51
6
= 48 x 6 = 288
5
Small groups = 160
52
4
= 160 x 4 = 640
42
Student/staff ratio = 500/20 = 25
43
Staff/assistant ratio = 15/5 = 3
56
Total score for quality based on distribution of effort = 640 + 288 + 640 = 768 + 320 + 960 = 3616
61
Standard score = 248
6
Laboratories = 192
53
4
= 192 x 4 = 768
57
Formulae for group weight = ½ x (15 – group size)
22
Group size = 10
5,6
Number of hours spent in small groups + laboratories = 160 + 192 = 352
7
Exams = 320
54
1
= 320 x 1 = 320
17
Years of curriculum = 5
Weight = ½ (15–10) = ½ x 5 = 2.5
58
Score for quality for groups size = Hours x weight = 352 x 2.5 = 880
8
Individual work = 240
55
4
= 240 x 4 = 960
59
Total quality score/year = 3616 + 880 = 4496
60
Total quality score for all years of curriculum = 4496 x 5 = 22480
Quality inde
= Score/248
= 22480/248
= 90.65


Student hours calculated in first column
Quality weights for curriculum
Weighted quality score
32
33
Student assistants = 5
1
Lecture = 640
1
50
= 640 x 1
= 640
44
= 20
4
Self instruction = 48
6
51
= 48 x 6
= 288
5
Small groups = 160
4
52
= 160 x 4
= 640
43
Staff/assistant ratio = 15/5 = 3
56
Total score for quality based on distribution of effort
= 640 + 288 + 640
= 768 + 320 + 960
= 3616
61
Standard score = 248
6
Laboratories = 192
4
53
= 192 x 4
= 768
22
5,6
Number of hours spent in small groups + laboratories
= 160 + 192 = 352
7
Exams = 320
1
54
= 320 x 1
= 320
14
Years of curriculum = 5
59
Score for quality for groups size
= Hours x weight
= 352 x 2.5
= 880
8
Individual work = 240
4
55
= 240 x 4
= 960
59
Total quality score/year
= 3616 + 880
= 4496
60
Total quality score for all years of curriculum
= 4496 x 5
= 22480
62
Quality index
= Score/248
= 22480/248
= 90.65

NUMERICAL SOLUTION TO PROBLEM ON USG

(page 3 of 3)



32
Teaching staff = 15
46
Average annual salary FTE = $ 26,000
21
Student in all years = 500
34
Staff in teaching and curriculum development = 15
47
Salaries for teaching and curriculum = 15 x 26,000 = 390,000
40
Curriculum development staff = 0
44
Average annual salary FTE = $ 8,000
48
Annual Salary cost of all personnel = 390,000 + 40,000 = $ 430,000
49
Salary cost per student = 430,000 / 500 = $ 860
33
Student Assistants = 5
45
Salary for student assistants = 5 x 8,000 = 40,000

UNIVERSITY OF UTRECHT BIOLOGY

	73-74	REFERENCE
GENERAL DATA		
SHORTAGE/SURPLUS T-HOURS (IN 100'S)	-207.60	A
STUDENT/STAFF RATIO	25.00	B
STAFF/ASSISTENT RATIO	3.00	C
CURRICULUM QUALITY	90.65	D
SALARY COSTS (USD, IN 10000'S)	43.00	E
SAL-COSTS/STUDENTS (USD, IN 100'S)	8.60	F
CURRICULUM		
STUDENTHOURS/YEAR (IN 100'S)	16.00	G
PERCENTAGE LECTURES	40.00	H
PERCENTAGE SELF INSTRUCTION	3.00	I
PERCENTAGE SMALL GROUPS	10.00	J
PERCENTAGE LABORATORY	12.00	K
PERCENTAGE EXAMINATIONS	20.00	L
PERCENTAGE INDIVIDUAL WORK	15.00	M
CURRICULUM YEARS	5.00	N
PERSONEL		
STAFF IN TEACHING	15.00	O
STUDENTASSISTENTS	5.00	P
STAFF IN CURRICULUM DEVELOPEMENT	0.00	Q
PERCENTAGE SPENT ON TEACHING	40.00	R
PERCENTAGE SPENT ON RESEARCH	30.00	S
PERCENTAGE SPENT ON OTHER ACTIVITIES	30.00	T
STUDENTS		
NUMBER OF STUDENTS	500.00	U
GROUPSIZE MAXIMUM	10.00	V
NUMBER OF GROUPS	50.00	W

Figure B.5

LIST OF DECISION VARIABLES

Decision Variable	Reference to Text, Section 3.	Reference to Output in Appendix, Figure B.4
1. Number of student hours of effort per year	Figure 13.1/1	G
2. Percentage of student effort distribution between	Figure 13.1/2	
. lectures		H
. special instruction		I
. small groups		J
. laboratories		K
. exams		L
. individual work		M
(must total to 100%)		
3. Years of study in curriculum	Figure 13.2/14 Figure 13.8/14	N
4. Number of students for all years	Figure 13.3/21 Figure 13.4/21	U
5. Maximum group size (at all levels)	Figure 13.3/22 Figure 13.8/22	V
6. Teaching staff available (full-time equivalent, i.e. FTE)	Figure 13.5/32 Figure 13.6/32	O
7. Student assistants available (in FTE)	Figure 13.5/33 Figure 13.6/33	P
8. Percentage of total effort of instructional staff available for teaching	Figure 13.5/37	R
9. Staff for curriculum development available (FTE)	Figure 13.6/40	Q

Key: The relevant box in each figure is identified after the figure number, e.g. Figure 13.1/1 is box 1 in Figure 13.1.

Figure B.6

LIST OF PARAMETERS

Parameter	Reference to text
1. Ratio of hours spent by instructional staff for each hour of student in lecture	Figure 13.2/9
2. Ratio of hours spent by instructional staff for each hour spent by student in self-instruction	Figure 13.2/11
3. Ratio of hours spent by instructional staff for each hour by student in small groups	Figure 13.3/16
4. Ratio of hours spent by instructional staff for each hour spent by students in laboratories	Figure 13.3/18
5. Ratio of instructional staff effort to student effort in exams	Figure 13.4/25
6. Ratio of instructional staff effort to student effort in individual work	Figure 13.4/27
7. Hours of total effort for each instructional staff for each academic year	Figure 13.5/35
8. Average annual salary for teaching student assistants	Figure 13.6/44
9. Average annual salary for teaching staff and staff in curriculum development	Figure 13.6/46
10. Weights/hr. by students for	
. lecture	Figure 13.7/50
. self-instruction	/51
. small groups	/52
. laboratories	/53
. exams	/54
. individual work	/55
11. Weights for group size	Figure 13.8/57
12. Standard score	Figure 13.8/61

Figure B.7

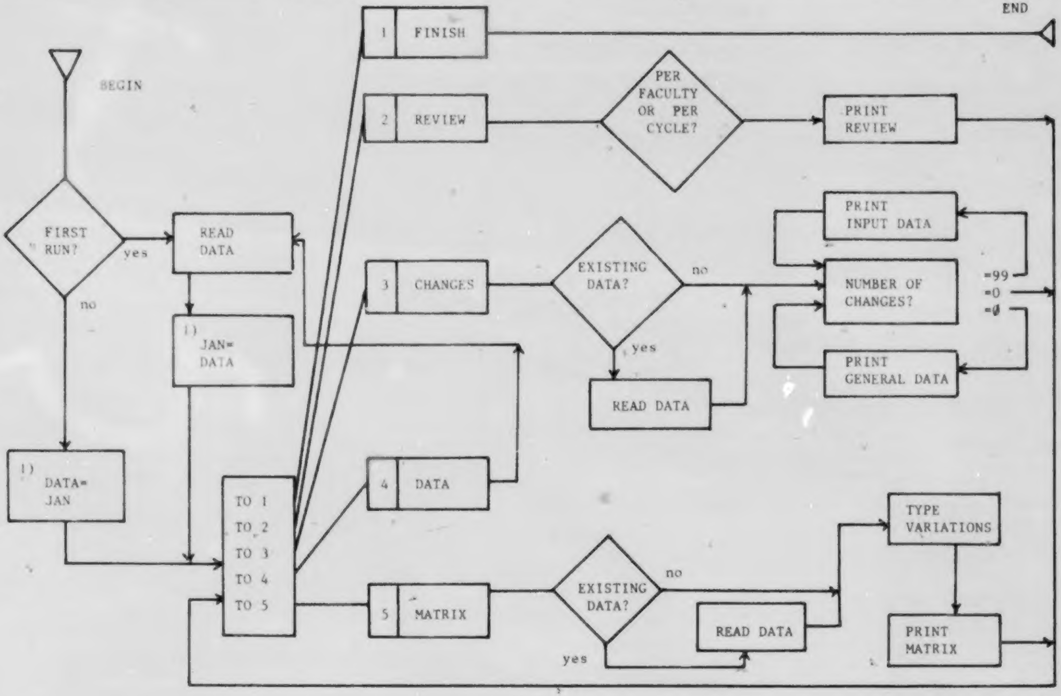
CALCULATED RESULTS IN USG

Items of calculated Results	Reference to sample in Appendix Figure B.4	Reference to text
Shortage/Surplus in hours	A	Figure 13.5/39
Student Staff Ratio	B	Figure 13.6/42
Staff/Assistant Ratio	C	Figure 13.6/43
Curriculum Quality (Index)	D	Figure 13.8/62
Salary Costs	E	Figure 13.6/48
Salary-Costs/Student	F	Figure 13.6/49

Appendix C

SYSTEMS DOCUMENTATION FOR USG

All that is available in English is a system-flow chart for the USG which follows.


BEGIN
FIRST RUN?
yes
no
READ DATA
1) JAN= DATA
1) DATA= JAN
TO 1
TO 2
TO 3
TO 4
TO 5
1 FINISH
END
2 REVIEW
PER FACULTY OR PER CYCLE?
PRINT REVIEW
3 CHANGES
EXISTING DATA?
no
yes
READ DATA
PRINT INPUT DATA
NUMBER OF CHANGES?
PRINT GENERAL DATA
=99
=0
=∅
4 DATA
5 MATRIX
EXISTING DATA?
no
yes
READ DATA
TYPE VARIATIONS
PRINT MATRIX

---

1) JAN = local file of central site. If INTERCOM is logged out during the game DATA has to be stored at central site as a file called "JAN".

Appendix D

PROGRAM LISTING FOR USG

The program listing for the USG that generates output in English appears in this Appendix. The program is designed for batch-processing. Another program for terminal processing is also available but not included in this appendix.

The program listing is not inconsistent with the logic flow discussed in Section 3 of Chapter 13. But the latter was written after the program and, for pedagogical and other reasons, it has a different ordering and aggregation of the calculations.

```
      DIMENSION CONTR(50)
      DIMENSION TEKST(7,5)
      REAL MDAT
      INTEGER P,Q,CONTR
      DO 700 IZ=1,5
C.....READ NAMES OF THE FACULTIES (5 CARDS)...........................00 00
      READ (5,701) (TEKST(I,IZ),I=1,7)
  700 CONTINUE
      DO 104 K=1,50
      CONTR(K)=0
  104 CONTINUE
      DO 106 I=1,5
      DO 106 J=1,10
      DO 106 K=1,23
      DATA(I,J,K)=0.
  106 CONTINUE
C
C     C H O I C E
C
  120 CONTINUE
C.....WHICH PROGRAM DO YOU WANT?.....................................01
C.....0001 FINISH...................................................
C.....0002 REVIEW...................................................
C.....0003 CHANGES..................................................
C.....0004 DATA.....................................................
C.....0005 MATRIX...................................................
      READ (5,202)IO
      IF (IO.NE.4) WRITE(6,600)
      GOTO (999,150,300,100,200) IO
C
C     D A T A
  100 CONTINUE
C.....WHICH FACULTY/CYCLE?...........................................02
      READ (5,202) P,Q
      IC=(P*10-10)+Q
      CONTR(IC)=1
C.....TYPE DATA!.....................................................03
      READ (5,204) (DATA(P,Q,I),I=3,16)
      X=DATA(P,Q,5)
      DATA(P,Q,5)=DATA(P,Q,6)
      DATA(P,Q,6)=DATA(P,Q,7)
      DATA(P,Q,7)=X
      CALL REKEN (P,Q,1,MDAT,DATA)
      DO 115 I=17,23
      DATA (P,Q,I)=MDAT(I)
  115 CONTINUE
      GOTO 120
C
C     R E V I E W
C
  150 CONTINUE
      CALL REVIEW(TEKST,DATA,MDAT,CONTR)
      GOTO 120
```

```
C     M A T R I X
C
  200 CONTINUE
      CALL MATRIX(DATA,MDAT,CONTR)
      GOTO 120
C
C     C H A N G E S
C
  300 CONTINUE
C.....DO YOU WANT TO CHANGE EXISTING DATA?  YES=0001,NO=0000.......02 02
      READ (5,202) I
      IF (I.EQ.0) GOTO 320
C.....WHICH FACULTY/CYCLE?.........................................03
      READ (5,202) J,K
      DO 310 II=3,16
      MDAT(II)=DATA(J,K,II)
  310 CONTINUE
      GOTO 330
  320 CONTINUE
C.....TYPE DATA!....................................................   03
      READ (5,204) (MDAT(IJ),IJ=3,16)
  330 CONTINUE
      CALL REKEN(P,Q,0,MDAT,CATA)
      WRITE (6,210) (MDAT(JJ),JJ=17,23)
  350 CONTINUE
C.....HOW MANY CHANGES?............................................04 04
      READ (5,202) IO
      IF (IO.NE.99) GOTO 355
      WRITE (6,213) (MDAT(K),K=3,16)
      GOTO 350
  355 IF (IO.GE.0.AND.IO.LE.16) GOTO 360
      WRITE (6,214)
      GOTO 350
  360 IF (IO.EQ.0) GOTO 399
      DO 375 I=1,IO
C.....TYPE VARIABLE NR/NEW VALUE....................................05 05
      READ (5,216) IP,QP
      MDAT(IP)=QP
  375 CONTINUE
C.....IF YOU WANT TO FINISH INSERT BLANK STOPCARD...................06 06
C.....OTHERWISE CONTINUE WITH DATACARD 04 04.......................
      CALL REKEN(P,Q,0,MDAT,DATA)
      WRITE (6,210) (MDAT(JJ),JJ=17,23)
      GOTO 350
  399 GOTO 120
C
C     F I N I S H
C
  999 CONTINUE
C
C
C
C     F O R M A T S
C
  107 FORMAT (I4,7A10)
  202 FORMAT (3I4)
```

```
        213 FORMAT (14F5.0)
        214 FORMAT (1H ,31HNUMBER CF DATA NCT RIGHT (3-16))
        216 FORMAT (I4,F4.0)
        600 FORMAT (1H1)
        701 FORMAT (7A6)
      C
            STOP
            END
      C
      C
      C
```

```
        SYMBOLIC REFERENCE MAP (R=1)

 ENTRY POINTS
  4102  USG

 VARIABLES      SN  TYPE            RELOCATION
  6725  CONTR       INTEGER     ARRAY              4500  DATA      REAL      ARRAY
  4465  I           INTEGER                        4471  IC        INTEGER
  4473  II          INTEGER                        4474  IJ        INTEGER
  4470  IO          INTEGER                        4476  IP        INTEGER
  4464  IZ          INTEGER                        4467  J         INTEGER
  4475  JJ          INTEGER                        4466  K         INTEGER
  6675  MDAT        REAL        ARRAY              4462  P         INTEGER
  4463  Q           INTEGER                        4477  QP        REAL
  7007  TEKST       REAL        ARRAY              4472  X         REAL

 FILE NAMES          MODE
     0  INPUT                  2036  OUTPUT                0  TAPE5     FMT         2036  TAPE6     FMT

 EXTERNALS           TYPE   ARGS
        MATRIX                3                       REKEN              5
        REVIEW                4

 STATEMENT LABELS
  4154  100                         0  104                             0  106
  4433  107     FMT  NO REFS        0  115                          4135  120
  4220  150                      4223  200                          4435  202     FMT
  4437  204     FMT              4441  210     FMT                  4443  213     FMT
  4445  214     FMT              4452  216     FMT                  4226  300
     0  310                      4243  320                          4245  330
  4251  350                      4260  355                          4266  360
     0  375                      4303  399                          4454  600     FMT
     0  700                      4456  701     FMT                  4304  999

 STATISTICS
   PROGRAM LENGTH   2756B    1518
    BUFFER LENGTH   4074B    2108
```

323

```
      INTEGER CCNTR
      REAL MOAT,MATR,NAAM
      DATA IIG1,IIG2,IIG3,IIG4,IIG5/14,16,15,10,3/
      DATA NAAM/6HHOURS ,6HST/STA,6HSTA/AS,6HQUAL  ,6HCOST  ,6HCOST/S/
      III=0
      IIA=0
C.....HOW MANY REVIEWS?.................................................02 02
      READ (5,5) IT
      DO 100 IIT=1,IT
      IF (IIT.GT.6) GOTO 100
      IF (IIT.NE.1) GOTO 101
  102 IF (III.GT.24) WRITE (6,103)
C.....INSERT VARIATIONS BY TYPING:.......................................
C.....INITIAL VALUE,LIMIT VALUE,STEP,NUMBER OF STEPS.....................
C.....PERCENTAGE TIME SPENT ON TEACHING:.................................03 03
      READ (5,5) IG2,IG3,IG4,IG5
C.....GROUPSIZE MAXIMUM:.................................................04 04
      READ (5,5) IH2,IH3,IH4,IH5
C.....NUMBER OF STUDENTS:................................................05 05
      READ (5,5) II2,II3,II4,II5
      III=IG5*IH5*II5
      IF (III.GT.24) GOTO 102
  104 IF (IIA.GT.6) WRITE (6,103)
C.....CURRICULUM YEARS:   (1 OR 2 STEPS ONLY)............................06 06
      READ (5,5) IJ2,IJ3,IJ4,IJ5
C.....STUDENTHOURS:   (3 OR 6 STEPS ONLY)................................07 07
      READ (5,5) IK2,IK3,IK4,IK5
      IIA=IJ5*IK5
      IF (IIA.NE.6) GOTO 104
  101 CONTINUE
C.....IN THE MATRIX VARIABLE NR:.........................................08 08
      READ (5,5) IIG6
      IF (IIG6.GT.23) GOTO 101
   44 CONTINUE
C.....ARE OTHER DATA EXISTING?  YES=0001,NO=0000.........................09 09
      READ (5,5) IY
      IF (IY.NE.1) GOTO 30
C.....WHICH FACULTY/CYCLE?...............................................10
      READ (5,5) IP,IQ
      IM=(IP*10-10)+IQ
      IF (CONTR(IP).NE.1) WRITE(6,43) IP,IQ
      IF (CONTR(IP).NE.1) GOTO 44
      DO 45 K=1,16
      MOAT(K)=DATA(IP,IQ,K)
   45 CONTINUE
      GOTO 70
   30 CONTINUE
C.....WHICH CURRICULUM?..................................................   10
      READ (5,23) (MOAT(K),K=4,9)
C.....WHICH PERSONEL?....................................................   11
C.....IF NUMBER OF REVIEWS NOT EQUAL 1 CONTINUE WITH DATACARD 08 08
      READ (5,23) (MOAT(K),K=11,13)
      ITEL=3
      DO 10 IG1=IG2,IG3,IG4
      DO 10 IH1=IH2,IH3,IH4
      DO 10 II1=II2,II3,II4
      DO 10 IJ1=IJ2,IJ3,IJ4
      DO 10 IK1=IK2,IK3,IK4
      MDAT(IIG1)=IG1
      MDAT(IIG2)=IH1
      MDAT(IIG3)=II1
      MDAT(IIG4)=IJ1
      MDAT(IIG5)=IK1
      CALL REKEN(P,Q,D,MDAT,DATA)
      ITEL=ITEL+1
      IF (IJ1.EQ.IJ3.AND.IK1.EQ.IK3) GOTO 16
      GOTO 15
   16 MATR(ITEL-8)=IG1
      MATR(ITEL-7)=IH1
      MATR(ITEL-6)=II1
   15 MATR(ITEL)=MDAT(IIG6)
      IF (IJ1.EQ.IJ3.AND.IK1.EQ.IK3) ITEL=ITEL+3
   10 CONTINUE
      ITEL=ITEL-3
      IF (IIT.NE.1) GOTO 21
      DO 32 IX=1,3
      IHULP(IX)=IJ2
      IHULP(IX+3)=IJ3
   32 CONTINUE
      DO 17 IX=1,6
      IXX=(IK2+(IX-1)*IK4)*100
      IHULP(IX+6)=IXX
      IF (IJ2.NE.IJ3.AND.IX.GT.3) IHULP(IX+6)=IHULP(IX+3)
   17 CONTINUE
      WRITE (6,210)
      WRITE (6,200) NAAM(IIG6-17)     ,(MCAT(K),K=4,9),(MDAT(K),K=11,13),
     ,(IHULP(K),K=1,6),(IHULF(K),K=7,12)
   21 CONTINUE
      IF (IIT.NE.1) WRITE(6,201) NAAM(IIG6-17),(MDAT(K),K=4,9),(MDAT(K),
     ,K=11,13)
      WRITE (6,19) (MATR(K),K=1,ITEL)
  100 CONTINUE
      WRITE (6,36)
      WRITE (6,36)
      WRITE (6,36)
C
C     F O R M A T S
C
    5 FORMAT (6I4)
   18 FORMAT (1H ,26X,I5,22X,I5,//,1H ,13X,6(4X,I5),/)
   19 FORMAT (1H ,3F5.0,6F9.2)
   23 FORMAT (6F4.0)
   31 FORMAT (1H ,13HCURRICULUM NR,I4,//)
   36 FORMAT (1H0)
   43 FORMAT (1H ,28HTHERE ARE NO DATA OF FACULTY,I2,6H CYCLE./  ,1H ,5H
     ,AGAIN)
  103 FORMAT (1H ,37HNUMBER OF STEPS NOT RIGHT! TRY AGAIN!)
  200 FORMAT (1H ,19HTABLE OF CHANGING  ,A10,/  ,1H ,10HCURRICULUM,4X,6F
201 FORMAT (1H ,/  ,/  ,1H ,19HTABLE OF CHANGING  ,A10,/  ,1H ,10HCURR
   ,ICULUM,4X,6F5.0,/,1H ,8HPERSONEL,6X,3F5.0,//)
210 FORMAT (1H1)
C
    RETURN
    END
C
C
```

```
      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  MATRIX

VARIABLES       SN  TYPE               RELOCATION
     0  CONTR        INTEGER     ARRAY      F.P.         0  DATA       REAL        ARRAY     F.P.
   631  IG1          INTEGER                           576  IG2        INTEGER
   577  IG3          INTEGER                           600  IG4        INTEGER
   601  IG5          INTEGER                          1172  IMULP      INTEGER     ARRAY
   632  IH1          INTEGER                           602  IH2        INTEGER
   603  IH3          INTEGER                           604  IH4        INTEGER
   605  IH5          INTEGER                           573  IIA        INTEGER
   310  IIG1         INTEGER                           311  IIG2       INTEGER
   312  IIG3         INTEGER                           313  IIG4       INTEGER
   314  IIG5         INTEGER                           622  IIG6       INTEGER
   572  III          INTEGER                           575  IIT        INTEGER
   633  II1          INTEGER                           606  II2        INTEGER
   607  II3          INTEGER                           610  II4        INTEGER
   611  II5          INTEGER                           634  IJ1        INTEGER
   612  IJ2          INTEGER                           613  IJ3        INTEGER
   614  IJ4          INTEGER                           615  IJ5        INTEGER
   635  IK1          INTEGER                           616  IK2        INTEGER
   617  IK3          INTEGER                           620  IK4        INTEGER
   621  IK5          INTEGER                           626  IM         INTEGER
   624  IP           INTEGER                           625  IQ         INTEGER
   574  IT           INTEGER                           630  ITEL       INTEGER
   640  IX           INTEGER                           641  IXX        INTEGER
   623  IY           INTEGER                           627  K          INTEGER
   642  MATR         REAL        ARRAY                   0  MDAT       REAL        ARRAY     F.P.
  1206  NAAM         REAL        ARRAY                 636  P          REAL
   637  Q            REAL

FILE NAMES          MODE
       TAPE5        FMT                 TAPE6      FMT

EXTERNALS            TYPE   ARGS
       REKEN                  5

STATEMENT LABELS
   475  5       FMT                  0  10                         166  15
   161  16                           0  17                         477  18      FMT  NO REFS
   504  19      FMT                254  21                         507  23      FMT
   113  30                         511  31      FMT  NO REFS         0  32
   515  36      FMT                517  43      FMT                 63  44
     0  45                         117  70                         267  100
    57  101                         25  102                        526  103     FMT
    43  104                        534  200     FMT                555  201     FMT
   567  210     FMT

STATISTICS
  PROGRAM LENGTH   1222B     658
```

```
      REAL IA,IB,IC,IE,IBT,ICT,MDAT
      INTEGER P,Q,M
      DO 10 II=3,16
      IA(II)=DATA(P,Q,II)
      IF (M.NE.1) IA(II)=MDAT(II)
   10 CONTINUE
      ITIT=0
      DO 15 K=4,9
      ITIT=ITIT+IA(K)
   15 CONTINUE
      IF (ITIT.NE.100.) WRITE (6,60)
      R=IA(15)/IA(16)
      IF (IA(15).LE.0) R=0
      IR=R
      IF ((IR-R).LT.0) IR=IR+1
      IA(17)=IR
      DO 20 I=4,9
      IE(I)=IA(I)*IA(3)
   20 CONTINUE
      IB(4)=IE(4)*IA(10)* 3.0/1.5
      IB(5)=IE(5)*IA(17)* 4.0/2.5
      IB(6)=IE(6)*IA(17)* 2.0/1.5
      IB(7)=IE(7)*IA(10)* 1.5/1.0
      IB(8)=IE(8)*IA(15)* 0.02
      IB(9)=IE(9)*IA(15)* 0.01
C
      PKWGR= 4.0 + (15 - IA(16)) * 0.5
C
      IC(4)=IE(4) * 1.0
      IC(5)=IE(5)*PKWGR
      IC(6)=IE(6)*PKWGR
      IC(7)=IE(7)*6.0
      IC(8)=IE(8)*1.0
      IC(9)=IE(9)*4.0
C
      IBT=0
      ICT=0
      DO 30 I=4,9
      IBT=IBT+IB(I)
      ICT=ICT+IC(I)
   30 CONTINUE
C
      IA(18)=((IA(11)+IA(12))*IA(14)*20. - IBT)/100.
      IA(19)=ICT*IA(10)/248.
      IA(20)=IA(15)/(IA(11)+IA(12)+IA(13))
      IA(21)=IA(11)/IA(12)
      IA(22)=((IA(11)+IA(13))*26.+IA(12)*8.)/10.
      IA(23)=IA(22)*100./IA(15)
      DO 40 IJ=17,23
      IF (M.EQ.1) DATA(P,Q,IJ)=IA(IJ)
      MDAT(IJ)=IA(IJ)
   40 CONTINUE
C
```

```
   60 FORMAT (1H ,22HCURRICULUM NOT CORRECT)
      RETURN
      END
C
C
C
```

```
    3  REKEN

VARIABLES     SN  TYPE            RELOCATION
    0  DATA        REAL       ARRAY      F.P.       230  I          INTEGER
  255  IA          REAL       ARRAY                 233  IB         REAL       ARRAY
  221  IBT         REAL                             244  IC         REAL       ARRAY
  222  ICT         REAL                             304  IE         REAL       ARRAY
  223  II          INTEGER                          232  IJ         INTEGER
  227  IR          INTEGER                          224  ITIT       INTEGER
  225  K           INTEGER                            0  M          INTEGER              F.P.
    0  MDAT        REAL       ARRAY      F.P.         0  P          INTEGER              F.P.
  231  PKNGR       REAL                               0  Q          INTEGER              F.P.
  226  R           REAL

FILE NAMES         MODE
       TAPE6      FMT

STATEMENT LABELS
    0  10                                   0  15                                 0  20
    0  30                                   0  40                               171  60      FMT

STATISTICS
  PROGRAM LENGTH     331B     217
```

```
      DIMENSION DATA(5,10,23)
      DIMENSION MOAT(23)
      DIMENSION CONTR(50)
      DIMENSION TEKST(7,5)
      DIMENSION ONDZ(5),REST(5),JF(5),IRT(5),IR(5,5),DAT(23,5)
      DIMENSION IIB(5),IIE(5)
      INTEGER SIM2,YEAR,CONTR
C
      YEAR=72
      IOUT=0
  100 CONTINUE
C.....ARE YOU GOING TO PRINT REVIEWS PER FACULTY OR PER CYCLE?.....02 02
C.....PER FACULTY=0001    PER CYCLE=0002...........................
      READ (5,306) ISW
      IF (ISW.LT.1.OR.ISW.GT.2) GOTO 100
  313 IF (IOUT.EQ.1) WRITE (6,314)
      IOUT=0
C.....HOW MANY REVIEWS?.............................................03 03
      READ (5,306) IFT
C.....ISW=1    WHICH FACULTIES?..................................04
C.....ISW=2    WHICH CYCLES?.....................................   04
      READ (5,306) (JF(I),I=1,IFT)
      DO 105 I=1,IFT
C.....HOW MANY COLUMNS?.............................................05 05
      READ (5,306) IRT(I)
C.....ISW=1    WHICH CYCLES SUCCESSIVELY?........................06
C.....ISW=2    WHICH FACULTIES SUCCESSIVELY?.....................   06
C.....IF NUMBER OF REVIEWS NCT EQUAL 1 CONTINUE WITH DATACARD 06
      IRTI=IRT(I)
      READ (5,306) (IR(I,J),J=1,IRTI)
C
  105 CONTINUE
C.....COSTS SUPPRESSED?.............................................07 07
      READ (5,306) ISUP
      IF (IOUT.EQ.1)  GOTO 313
      WRITE (6,36)
      WRITE (6,36)
      WRITE (6,36)
      WRITE (6,36)
      DO 200 I=1,IFT
      IP=JF(I)
      SIM2=IRT(I)
      IF (ISW.EQ.2) GOTO 151
      DO 210 KL=1,5
      IIB(KL)=IR(I,KL)+YEAR
      IIE(KL)=-IR(I,KL)-YEAR-1
  210 CONTINUE
      WRITE (6,81) (TEKST(K,IP),K=2,7),(IIB(II),II=1,SIM2)
      WRITE (6,80) (IIE(II),II=1,SIM2)
      GOTO 154
  151 IF (IP.GE.6) GOTO 152
      IAB=IP+YEAR
      IIAB=IAB+1
      WRITE (6,74) IAB,IIAB
      GOTO 153
  152 IAB=I
```

```
      IF (ISW.EQ.2) GOTO 170
      DAT(II,J)=DATA(IP,JJ,II)
      GOTO 175
  170 DAT(II,J)=DATA(JJ,IP,II)
  175 CONTINUE
      DO 176 K=1,SIM2
      ONDZ(K)=70.-DAT(14,K)
      REST(K)=30.
  176 CONTINUE
C
C     P R I N T   R E V I E W
C
      WRITE (6,36)
      WRITE (6,92) (DAT(18,J),J=1,SIM2)
      WRITE (6,90) (DAT(20,J),J=1,SIM2)
      WRITE (6,91) (DAT(21,J),J=1,SIM2)
      WRITE (6,79) (DAT(19,J),J=1,SIM2)
      IF (ISUP.EQ.1) GOTO 99
      WRITE (6,97) (DAT(22,J),J=1,SIM2)
      WRITE (6,98) (DAT(23,J),J=1,SIM2)
   99 CONTINUE
      WRITE (6,36)
      WRITE (6,82) (DAT(3,J),J=1,SIM2)
      WRITE (6,84) (DAT(4,J),J=1,SIM2)
      WRITE (6,86) (DAT(7,J),J=1,SIM2)
      WRITE (6,85) (DAT(5,J),J=1,SIM2)
      WRITE (6,87) (DAT(6,J),J=1,SIM2)
      WRITE (6,88) (DAT(8,J),J=1,SIM2)
      WRITE (6,89) (DAT(9,J),J=1,SIM2)
      WRITE (6,70) (DAT(10,J),J=1,SIM2)
      WRITE (6,36)
      WRITE (6,71) (DAT(11,J),J=1,SIM2)
      WRITE (6,73) (DAT(12,J),J=1,SIM2)
      WRITE (6,72) (DAT(13,J),J=1,SIM2)
      WRITE (6,75) (DAT(14,J),J=1,SIM2)
      WRITE (6,76) (ONDZ(J),J=1,SIM2)
      WRITE (6,77) (REST(J),J=1,SIM2)
      WRITE (6,36)
      WRITE (6,93) (DAT(15,J),J=1,SIM2)
      WRITE (6,94) (DAT(16,J),J=1,SIM2)
      WRITE (6,78) (DAT(17,J),J=1,SIM2)
      WRITE (6,36)
      WRITE (6,36)
      WRITE (6,36)
      WRITE (6,36)
  200 CONTINUE
C
C     F O R M A T S
C
   36 FORMAT (1H0)
   70 FORMAT (1H ,16HCURRICULUM YEARS,21X,5F7.2)
   71 FORMAT (1H ,8HPERSONEL,/  ,1H ,17HSTAFF IN TEACHING,20X,5F7.2)
   72 FORMAT (1H ,32HSTAFF IN CURRICULUM DEVELOPEMENT,5X,5F7.2)
   73 FORMAT (1H ,17HSTUDENTASSISTENTS,20X,5F7.2)
   74 FORMAT (1H ,13HACADEMIC YEAR,I4,1H-,I4,//)
   75 FORMAT (1H ,28HPERCENTAGE SPENT ON TEACHING,9X,5F7.2)
   76 FORMAT (1H ,28HPERCENTAGE SPENT ON RESEARCH,9X,5F7.2)
   77 FORMAT (1H ,36HPERCENTAGE SPENT ON OTHER ACTIVITIES,1X,5F7.2)
   78 FORMAT (1H ,16HNUMBER OF GROUPS,21X,5F7.2)
   79 FORMAT (1H ,18HCURRICULUM QUALITY,19X,5F7.2)
   80 FORMAT (1H+,37X,5I7)
   81 FORMAT (1H ,6A6,///,35X,5I7)
   82 FORMAT (1H ,10HCURRICULUM,/,1H ,28HSTUDENTHOURS/YEAR (IN 100'S),9X
     ,,5F7.2)
   84 FORMAT (1H ,19HPERCENTAGE LECTURES,18X,5F7.2)
   85 FORMAT (1H ,23HPERCENTAGE SMALL GROUPS,14X,5F7.2)
   86 FORMAT (1H ,27HPERCENTAGE SELF INSTRUCTION,10X,5F7.2)
   87 FORMAT (1H ,21HPERCENTAGE LABORATORY,16X,5F7.2)
   88 FORMAT (1H ,23HPERCENTAGE EXAMINATIONS,14X,5F7.2)
   89 FORMAT (1H ,26HPERCENTAGE INDIVIDUAL WORK,11X,5F7.2)
   90 FORMAT (1H ,19HSTUDENT/STAFF RATIO,18X,5F7.2)
   91 FORMAT (1H ,21HSTAFF/ASSISTENT RATIO,16X,5F7.2)
   92 FORMAT (1H ,12HGENERAL DATA,/,1H ,35HSHORTAGE/SURPLUS T-HOURS (IN
     ,100'S),2X,5F7.2)
   93 FORMAT (1H ,8HSTUDENTS,/  ,1H ,18HNUMBER OF STUDENTS,19X,5F7.2)
   94 FORMAT (1H ,17HGROUPSIZE MAXIMUM,20X,5F7.2)
   95 FORMAT (1H ,12HESTIMATES NR,I4,//)
   96 FORMAT (1H ,28X,10HFACULTY NR,5(6X,I1))
   97 FORMAT (1H ,30HSALARY COSTS (USD, IN 10000'S),7X,5F7.2)
   98 FORMAT (1H ,34HSAL-COSTS/STUDENTS (USD, IN 100'S),3X,5F7.2)
  306 FORMAT (5I4)
  311 FORMAT (1H ,28HTHERE ARE NO DATA OF FACULTY,I2,6H CYCLE,I2,11H FOR
     , REVIEW,I2)
  312 FORMAT (1H ,26HTHERE ARE NO DATA OF CYCLE,I2,8H FACULTY,I2,11H FOR
     , REVIEW,I2)
  314 FORMAT (1H ,9HTRY AGAIN)
      RETURN
      END
     3  REVIEW

VARIABLES      SN  TYPE            RELOCATION
     0  CONTR      INTEGER    ARRAY     F.P.          1602  DAT        REAL       ARRAY
     0  DATA       REAL       ARRAY     F.P.          1512  I          INTEGER
  1522  IAB        INTEGER                            1511  IFT        INTEGER
  1521  II         INTEGER                            1523  IIAB       INTEGER
  1765  IIB        INTEGER    ARRAY                   1772  IIE        INTEGER    ARRAY
  1507  IOUT       INTEGER                            1516  IP         INTEGER
  1551  IR         INTEGER    ARRAY                   1544  IRT        INTEGER    ARRAY
  1513  IRTI       INTEGER                            1515  ISUP       INTEGER
  1510  ISW        INTEGER                            1514  J          INTEGER
  1537  JP         INTEGER    ARRAY                   1524  JJ         INTEGER
  1520  K          INTEGER                            1517  KL         INTEGER
     0  MDAT       INTEGER    ARRAY     F.P.          1525  ONDZ       REAL       ARRAY
  1532  REST       REAL       ARRAY                   1505  SIM2       INTEGER
     0  TEKST      REAL       ARRAY     F.P.          1506  YEAR       INTEGER

FILE NAMES         MODE
        TAPE5      FMT                     TAPE6      FMT

STATEMENT LABELS
  1225  36        FMT                     1230  70         FMT                     1235  71         FMT
  1243  72        FMT                     1251  73         FMT                     1256  74         FMT
  1263  75        FMT                     1271  76         FMT                     1277  77         FMT
  1306  78        FMT                     1313  79         FMT                     1320  80         FMT
  1323  81        FMT                     1326  82         FMT                     1335  84         FMT
  1342  85        FMT                     1347  86         FMT                     1355  87         FMT
  1362  88        FMT                     1367  89         FMT                     1375  90         FMT
  1402  91        FMT                     1407  92         FMT                     1417  93         FMT
  1425  94        FMT                     1432  95         FMT                     1436  96         FMT
  1442  97        FMT                     1450  98         FMT                      340  99
    17  100                                  0  105                                 140  151
   147  152                                152  153                                 166  154
   204  170                                211  175                                   0  176
     0  200                                  0  210                                1456  306        FMT
  1460  311       FMT  NO REFS            1470  312        FMT  NO REFS              25  313
  1500  314       FMT

STATISTICS
  PROGRAM LENGTH    2010B    1032
```

```
FWA OF THE LOAD                101                              36216B WORDS WERE REQUIRED FOR LOADING
LWA+1 OF THE LOAD            25313

TRANSFER ADDRESS -- USG                 4203

NO. TABLE MOVES                 76


PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK          ADDRESS    LENGTH          FILE                           PREFIX TABLE CONTENTS

USG                101      7052          LGO        23/07/74  16.34.05. SCOPE 3.4 FTN     4.0F357 6464  I
                                                     OPT=1
MATRIX            7153      1222          LGO        23/07/74  16.34.08. SCOPE 3.4 FTN     4.0F357 6464  I
                                                     OPT=1
REKEN            10375       331          LGO        23/07/74  16.34.13. SCOPE 3.4 FTN     4.0F357 6464  I
                                                     OPT=1
REVIEW           10726      2010          LGO        23/07/74  16.34.19. SCOPE 3.4 FTN     4.0F357 6464  I
                                                     OPT=1
/Q8.IO./         12736       134
/IOCON./         13072        42
COMIO=           13134       134       SL-FORTRAN   11/11/73  16.39.19. SCOPE 3.4 COMPASS 3.0-361
                                                     COMMON CODED I/O ROUTINES AND CONSTANTS.63-CHAR
FLTIN=           13270       153       SL-FORTRAN   11/11/73  16.39.43. SCOPE 3.4 COMPASS 3.0-361
                                                     COMMON FLOATING INPUT CONVERTER.
FMTAP=           13443       345       SL-FORTRAN   11/11/73  16.39.51. SCOPE 3.4 COMPASS 3.0-
                                                     CRACK APLIST AND FORMAT FOR KODER/KRAKER.
INCOM=           14010       260       SL-FORTRAN   11/11/73  16.40.14. SCOPE 3.4 COMPASS 3.0-361
                                                     COMMON INPUT FORMATTING CODE
INPC=            14270       163       SL-FORTRAN   11/11/73  16.40.30. SCOPE 3.4 COMPASS 3.0-361
                                                      FORMATTED READ FORTRAN RECORD
KODER=           14453       460       SL-FORTRAN   11/11/73  16.40.42. SCOPE 3.4 COMPASS 3.0-361
                                                     OUTPUT FORMAT INTERPRETER.
OUTCOM=          15133       141       SL-FORTRAN   11/11/73  16.41.56. SCOPE 3.4 COMPASS 3.0-361
                                                     COMMON OUTPUT CODE
GOTOER=          15274        13       SL-FORTRAN   11/11/73  16.42.50. SCOPE 3.4 COMPASS 3.0-361
                                                     COMPUTED GO TO ERROR PROCESSOR.
FLTOUT=          15307       312       SL-FORTRAN   11/11/73  16.39.46. SCOPE 3.4 COMPASS 3.0-361
                                                     COMMON FLOATING OUTPUT CODE
FORSYS=          15621       536       SL-FORTRAN   11/11/73  16.39.56. SCOPE 3.4 COMPASS 3.0-361
                                                     FORTRAN OBJECT LIBRARY UTILITIES.
GETFIT=          16357        33       SL-FORTRAN   11/11/73  16.40.12. SCOPE 3.4 COMPASS 3.0-361
                                                     LOCATE AN FIT GIVEN A FILE NAME.
KRAKER=          16412       373       SL-FORTRAN   11/11/73  16.40.49. SCOPE 3.4 COMPASS 3.0-361
                                                      PROCESS FORMATTED FORTRAN INPUT
OUTC=            17005       171       SL-FORTRAN   11/11/73  16.41.49. SCOPE 3.4 COMPASS 3.0-361
                                                      FORMATTED WRITE FORTRAN RECORD
/JMPS.RM/        17176        14
LBUF.SQ          17212       133       SL-SYSIO     21/08/73  22.06.52. SCOPE 3.4 COMPASS 3.73219
/CON.RM/         17345         6
CIO.RM           17353        25       SL-SYSIO     21/08/73  22.07.48. SCOPE 3.4 COMPASS 3.73219
/AB3.RM/         17400        10
CHWR.SQ          17410         7       SL-SYSIO     21/08/73  22.07.56. SCOPE 3.4 COMPASS 3.73219
/PUT.RT/         17417        11
```

```
 RLEQ.RM         17565         42         SL-SYSIO      21/08/73  22.08.47. SCOPE 3.4 COMPASS 3.73219
 /CLSF.FO/       17627          7
 CLSF.RM         17636         23         SL-SYSIO      21/08/73  22.09.50. SCOPE 3.4 COMPASS 3.73219
 /GET.BT/        17661          5
 BTRT.SQ         17666        117         SL-SYSIO      21/08/73  22.11.12. SCOPE 3.4 COMPASS 3.73219
 LXER.SQ         20005        203         SL-SYSIO      21/08/73  22.11.41. SCOPE 3.4 COMPASS 3.73219
 /SKFL.FO/       20210          7
 SKFL.SQ         20217         46         SL-SYSIO      21/08/73  22.12.02. SCOPE 3.4 COMPASS 3.73219
 MOVE.RM         20265         32         SL-SYSIO      11/02/74  10.27.09. SCOPE 3.4 COMPASS 3.73219
 WAR.SQ          20317        256         SL-SYSIO      11/02/74  10.27.53. SCOPE 3.4 COMPASS 3.73219
 ERR.RM          20575        367         SL-SYSIO      21/08/73  22.07.49. SCOPE 3.4 COMPASS 3.73219
 MCT.RM          21164        233         SL-SYSIO      21/08/73  22.07.56. SCOPE 3.4 COMPASS 3.73219
 /OPEN.FO/       21417          7
 OPEN.RM         21426        301         SL-SYSIO      21/08/73  22.08.10. SCOPE 3.4 COMPASS 3.73219
 OPEN.SQ         21727        230         SL-SYSIO      21/08/73  22.08.22. SCOPE 3.4 COMPASS 3.73219
 CLSF.SQ         22157        136         SL-SYSIO      21/08/73  22.09.52. SCOPE 3.4 COMPASS 3.73219
 /CLSV.FO/       22315          7
 CLSV.SQ         22324        115         SL-SYSIO      21/08/73  22.10.01. SCOPE 3.4 COMPASS 3.73219
 /GET.RT/        22441         11
 Z.SQ            22452         76         SL-SYSIO      21/08/73  22.10.48. SCOPE 3.4 COMPASS 3.73219
 FSU.SQ          22550        111         SL-SYSIO      21/08/73  22.11.05. SCOPE 3.4 COMPASS 3.73219
 /PUT.FO/        22661          7
 PUT.SQ          22670       1266         SL-SYSIO      11/02/74  10.27.12. SCOPE 3.4 COMPASS 3.73219
 /GET.FO/        24156          7
 GET.SQ          24165       1067         SL-SYSIO      11/02/74  10.28.06. SCOPE 3.4 COMPASS 3.73219
 SYS.RM          25254         37         SL-NUCLEUS    16/09/73  10.13.40. SCOPE 3.4 COMPASS 3.73219
                                                        PROCESS SYSTEM REQUEST.


        2.288 CP SECONDS LOAD TIME
```

PART FOUR

SUMMARY AND CONCLUSIONS

Of the many planning models implemented in the U.S., CAMPUS and RRPM are the most generalized and comprehensive. They both include the non-academic sector as well as being cost and costing models. In contrast, HIS (West Germany), MSAR (Portugal), and TUSS (Holland) are largely resource allocation models concerned primarily with the academic sector. Of all these models CAMPUS is by far the most comprehensive, complex and expensive. RRPM is conceptually the simplest, the most aggregate, the cheapest to run and maintain, and by far the best validated and most widely used.

All the models discussed in this book use the program concept of planning and budgeting. They have a great similarity in their basic computations in spite of the fact that except for MSAR they were independently developed. MSAR adopted the basic concepts of CAMPUS and RRPM and thereby demonstrated the portability and transferability of concepts across national frontiers.

The text, in comparing the five models, points out differences between the models, and discusses special features and submodels of each. Portability potential, especially the faculty flow concept in CAMPUS VIII and the Faculty Assignment module of HIS-A have been identified.

To support the resource allocation model, numerous other models and projects are needed,as discussed in Part Two. Some relate to the front end of the model, that is, they relate to the generation of data needed by the model. These include the Cost Finding Principles Project, the Space Analysis Manual, the Faculty Activity Analysis Manual, the Faculty Activity Analysis Procedures, and the Student Flow Model. The other types of models and projects more related to analysis of planning and budgetary information are Program Budget Manual, the Resource Utilization Analysis Manual, Departmental Management Systems, and the not yet fully implemented project of Outcome and Benefit Analysis Project. All these are needed for institutional models.

CAMPUS and RRPM are concerned with exchange of information between institutions within a region and within a nation. The need for such an exchange capability was the main incentive for the development of RRPM. The output of this model was envisaged for use at an institutional level as well as at state and national levels. To achieve such integration of data use, the National Center for Higher Education in the U.S. (NCHEMS) needed to develop additional planning related models and projects at the statewide and national level maintaining upward compatibility from the institutional through the national level. Such projects include the Program Classification Structure which contains national coding for academic disciplines compatible with coding in most states; a set of Data Element Dictionaries and program measures for institutional and statewide levels; a statewide and national student flow model; national classification of higher education employees by assignment; the National Manpower Accounting Manual; numerous studies related to national financing of higher education; and finally a set of procedures for cost information exchange. These models and projects enable a nationwide integration or exchange of planning and budgetary data. One graphic representation of the interrelationship is shown in Figure 14.1 (Hussain and Freytag, 1973:131)(1).

Another national attempt with planning models is being done by HIS in West Germany. The HIS approach differs from NCHEMS in that it starts with functional applications at the institutional level, such as the student file and personnel file, with plans to integrate these applications with decision making at the statewide and national levels. In contrast, NCHEMS is not concerned with functional applications, leaving institutions to develop and integrate functional applications upwards.

Once developed, models (resource allocation or planning related models) and projects must be implemented. This requires at least four distinct steps: data generation (creation, making data stable, and preprocessing it for validity and completeness); running the model on local equipment; validating the model; and finally educating the user to interpret and use the output. The first two steps are somewhat technical and are the main responsibility of the analyst. The second two steps involve the administrator/manager who uses the model. He must ensure that the model is believable, relevant, flexible, and communicable.

An educational program must be designed for each model being developed with careful thought given to the content, audience, and media of instruction to be certain the model will be understood and properly used.

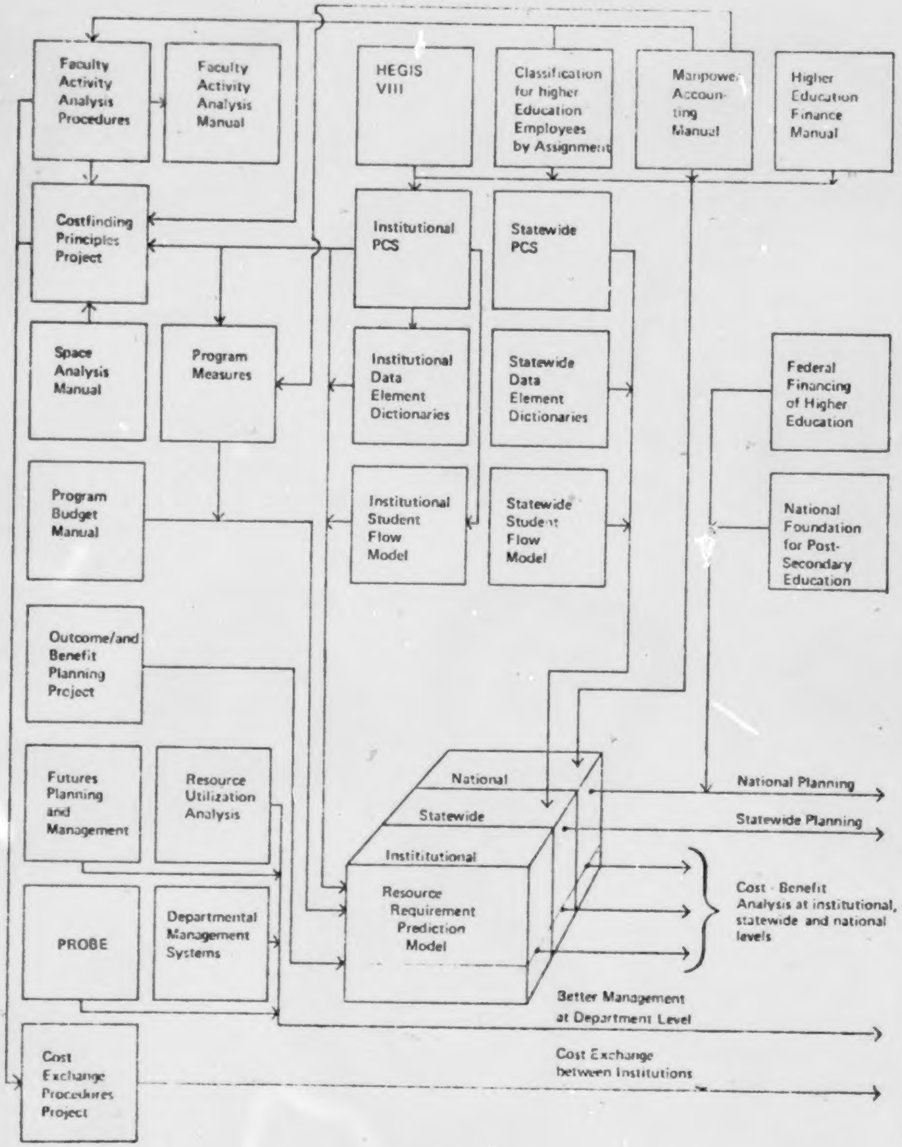
Sometimes changes within an institution are necessary for planning models to be efficient and effective. These may include structural changes, such as merging or better coordination between offices

---

1) For another representation but not a graphic one, see Jones and Kirschling (1973).

Figure 14.1

OVERVIEW OF PRODUCTS OF NCHEMS

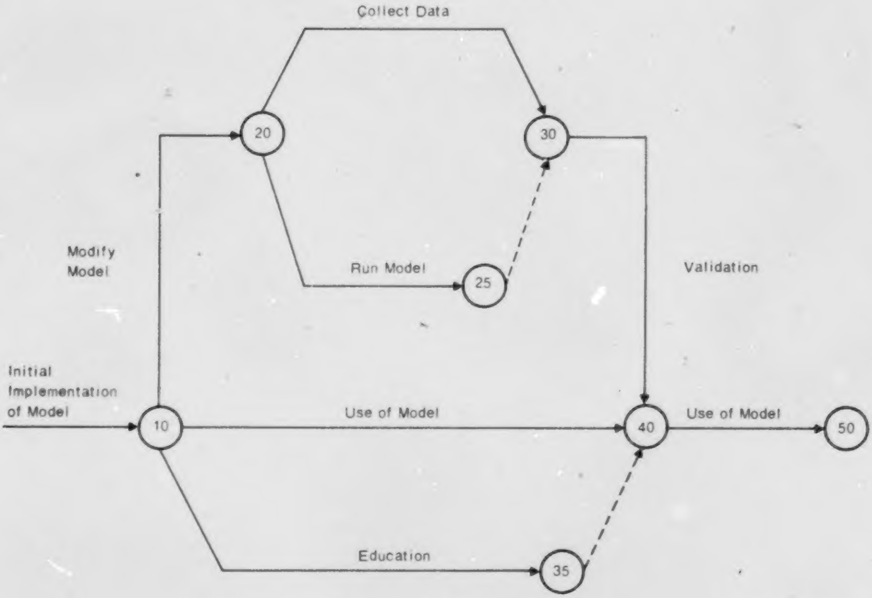

Faculty Activity Analysis Procedures
Faculty Activity Analysis Manual
HEGIS VIII
Classification for higher Education Employees by Assignment
Manpower Accounting Manual
Higher Education Finance Manual
Costfinding Principles Project
Institutional PCS
Statewide PCS
Space Analysis Manual
Program Measures
Institutional Data Element Dictionaries
Statewide Data Element Dictionaries
Federal Financing of Higher Education
Program Budget Manual
Institutional Student Flow Model
Statewide Student Flow Model
National Foundation for Post-Secondary Education
Outcome/and Benefit Planning Project
Futures Planning and Management
Resource Utilization Analysis
National
Statewide
Instititutional
Resource Requirement Prediction Model
National Planning
Statewide Planning
Cost - Benefit Analysis at institutional, statewide and national levels
PROBE
Departmental Management Systems
Better Management at Department Level
Cost Exchange Procedures Project
Cost Exchange between Institutions

of planning, budgeting and institution research to ensure that users of the planning models have access to the data and computing facility of the institution. Other organization changes may include the addition of personnel such as the hiring of a data administrator responsible for the creation, control and security of data, and hiring of a policy analyst to be the liaison between the model and its many users.

Once models are implemented they must be "maintained". This involves making modifications when necessary and recycling through the process of implementation. This maintenance and recycling process is shown in Figure 14.2. Maintenance activities include: making modifications (activity 10-20 in Figure 14.2); collecting data (activity 20-30); running the new version on institutional equipment (activity 20-25 with 25-30 as a dummy); and revalidating the new model version (activity 30-40). These activities can be done while the existing model is operational (activity 10-40) and while management is being trained on the new modification (activity 10-35). When the new version is satisfactorily validated the old version is phased-out and the new version can then be used (activity 40-50).

Figure 14.2

MAINTAINING MODEL



The reasons for modification can be many: a change in technology (model techniques or computing equipment); a change in environment (institutional or external environment); a change in the decision maker or his style of management; or merely an evaluation that shows the model to be inadequate. Any one or more of these reasons could require modification of the model and the recycling of the implementation process. In practice, modification is usually a continuous process when models are used.

A planning model greatly affects the flow and nature of planning and budgeting information. For example, it can affect the cycle and style of decision making of users of the model. The decision maker must therefore know the model, its assumptions, its basic logic, and its constraints in order to understand the model's output. He must understand the concept of simulation as well as the limitations and capabilities of simulation. He must know how to use simulation models effectively and efficiently because running simulation models is very expensive, especially in computer time.

Playing a simulation game is a useful training tool for decision makers. It can help model users understand what relationships exist within the model, how data is synthesized, and provide exercises in making trade-offs to achieve desired results.

Users of existing planning models in education may find the models limited in their capabilities. Current models are not yet optimizing models and do not identify the best solution to planning problems. Nor do they consider the benefits and outcomes of any solution. The models merely provide the user and decision maker with resource information on which to make allocation decisions. However, the model does force the user to structure his decision-making process and value system. The model does provide information on the consequences of possible choices in terms of programs within a time horizon. Such information, when tempered with experience, judgement and the weighing of qualitative factors, can help managers make economically rational decisions.

REFERENCE

Jones, D.P. and W. Kirschling, NCHEMS Project Interrelationships, (Boulder, Colorado: NCHEMS at WICHE, 1973).

APPENDICES

Appendix I: CAMPUS/COLORADO: The Logic of the Model: A Self-Instructional Approach 334

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Appendix I

CAMPUS/COLORADO: THE LOGIC OF THE MODEL

A Self-Instructional Approach

INTRODUCTION

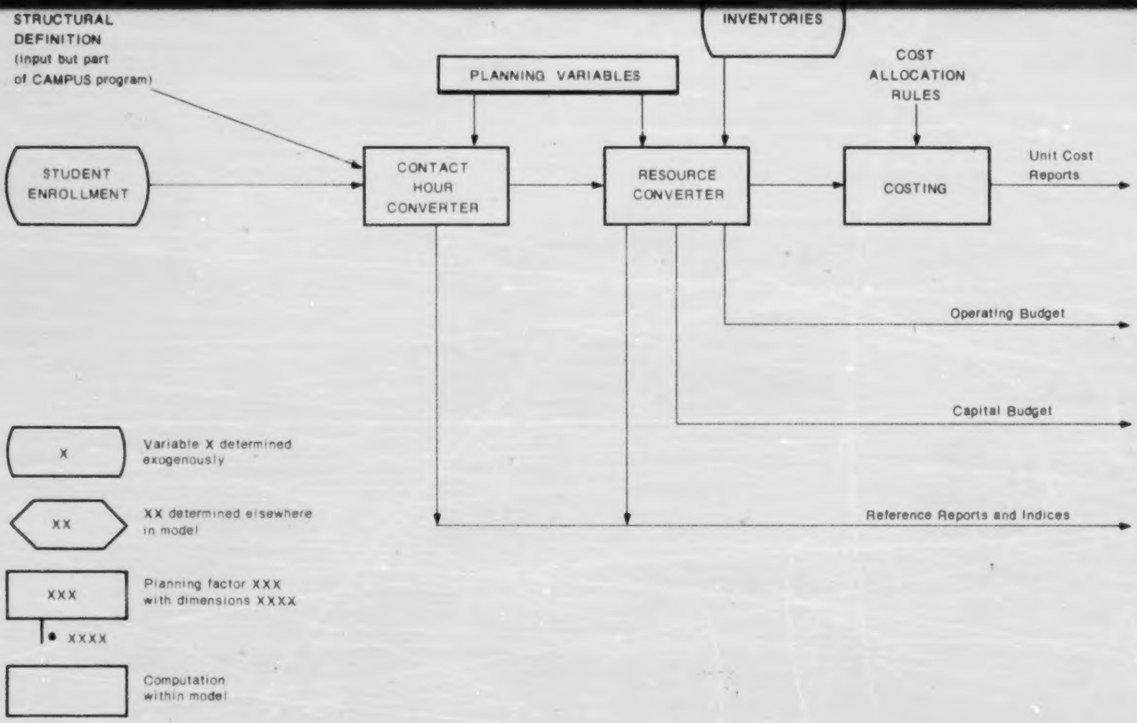
The purpose of this appendix is to facilitate an understanding of the logic of the CAMPUS/COLORADO model. This is attempted in two ways. One is a representation of the system's flow in a block-diagram form. It is designed to be self-explanatory. Second, for a further understanding, there is a set of numerical exercises that elaborate the logic of the model in small logical segments and display the solutions to each exercise.

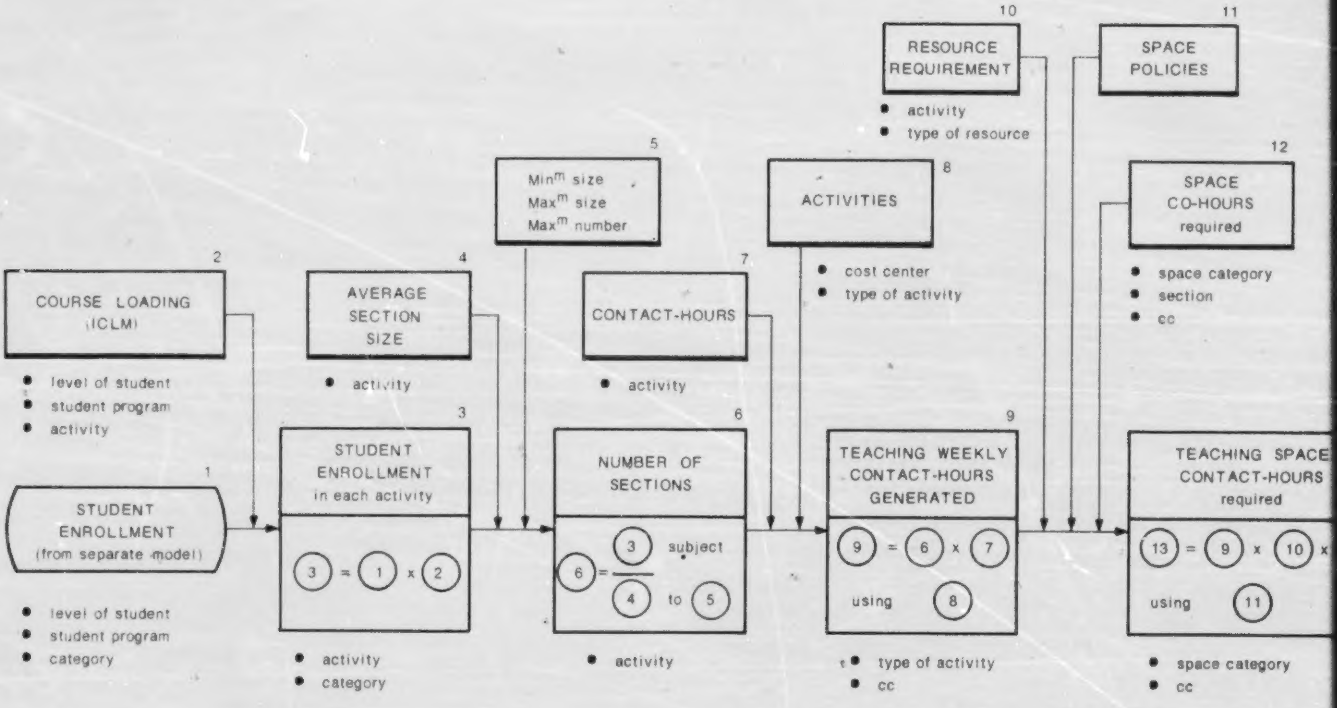
In order to keep the arithmetic easy, the institutional environment and its data are assumed to be simple, and hence not necessarily representative of any institution in Colorado. This enables an emphasis on the concepts rather than the mathematics of solution.

Each exercise follows a standard format: the problem is stated along with all the relevant data and policy variables, a worksheet is provided, followed by a solution. In most cases the worksheet and solution are schematic and each symbol numbered. These correspond to the diagram and symbol numbers of the block diagram of the logic of the model that precedes the exercises. In cases where the schematic format is not most appropriate for a worksheet a separate diagram showing the logic is provided.

The sequence of exercises follows the logic of the CAMPUS/COLORADO model. It starts with student loading in exercise 1 and goes through all the basic types of computations resulting in cost per student-contact-hour in exercise 7. Exercises 8 and 9 are concerned with calculating direct costs and unit costs of student programs. These would be of special interest to academic personnel. Problem 10 shows an alternate way of student loading than that used in problem 1.

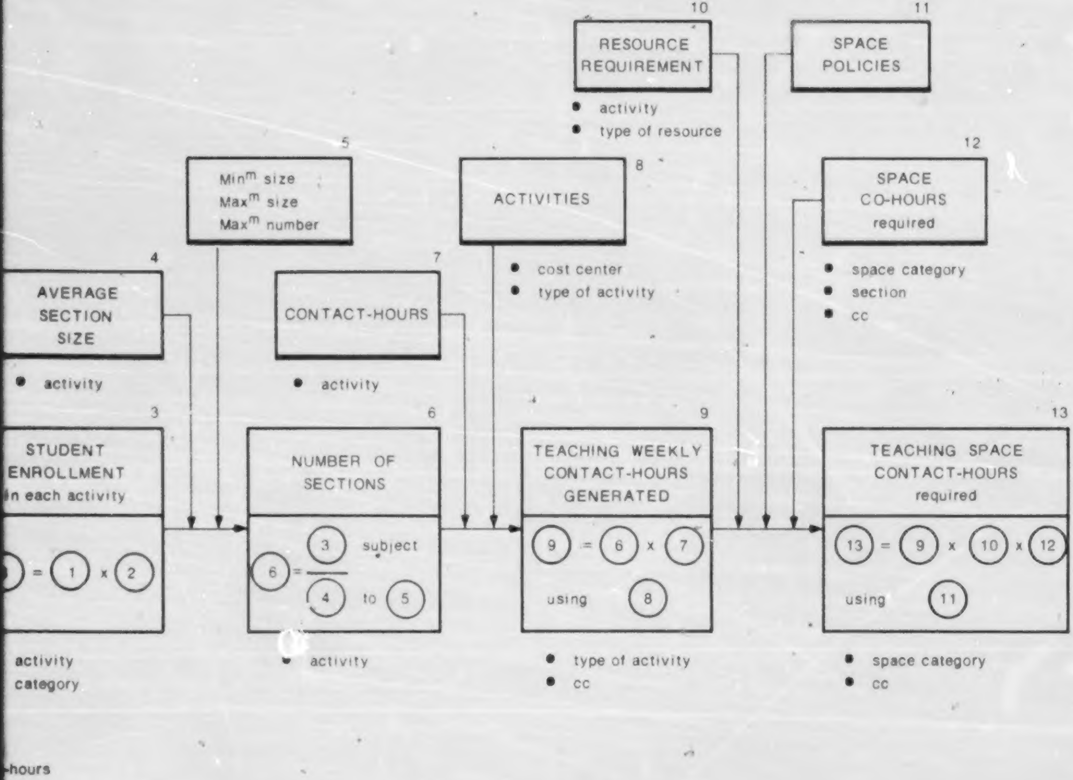
There are no mathematical prerequisites for studying this document. It is expected, however, that the reader should have some previous knowledge of CAMPUS or have read Chapter 2.

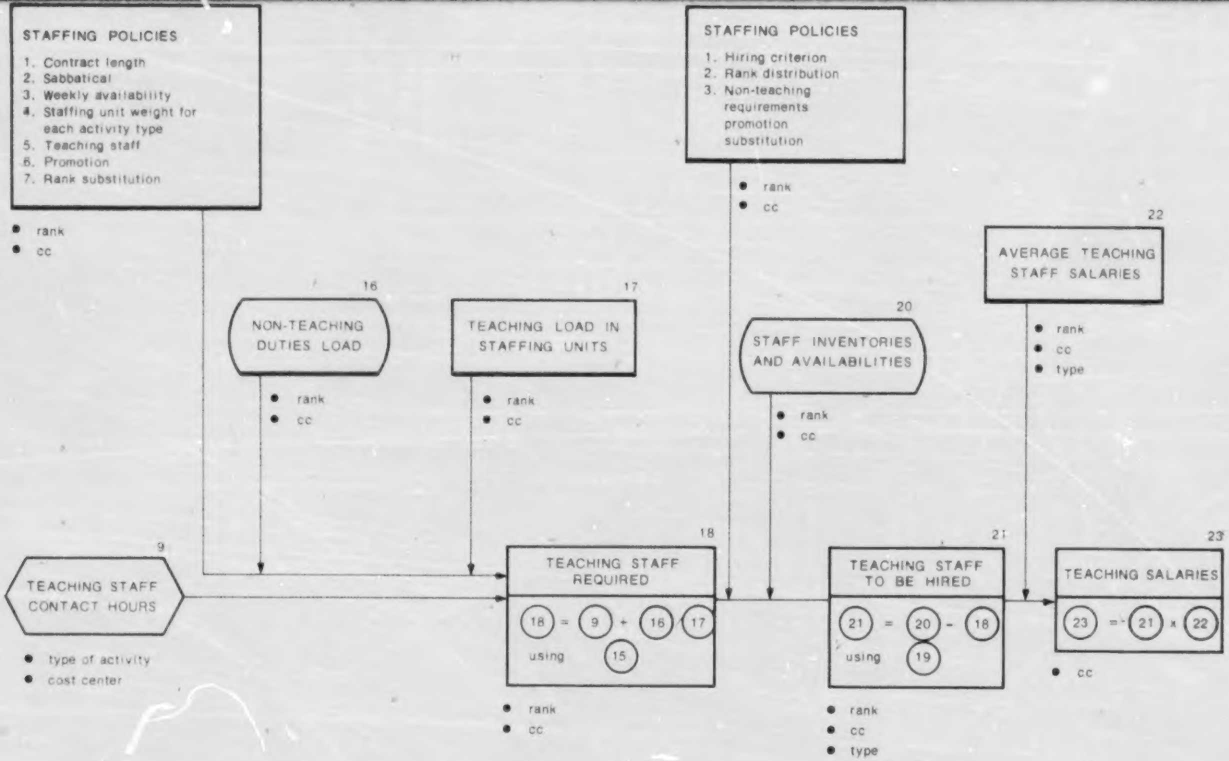

STRUCTURAL DEFINITION (input but part of CAMPUS program)
INVENTORIES
PLANNING VARIABLES
COST ALLOCATION RULES
STUDENT ENROLLMENT
CONTACT HOUR CONVERTER
RESOURCE CONVERTER
COSTING
Unit Cost Reports
Operating Budget
Capital Budget
Reference Reports and Indices
X
Variable X determined exogenously
XX
XX determined elsewhere in model
XXX
Planning factor XXX with dimensions XXXX
XXXX
Computation within model



1
STUDENT ENROLLMENT (from separate model)
• level of student
• student program
• category
2
COURSE LOADING (ICLM)
• level of student
• student program
• activity
3
STUDENT ENROLLMENT in each activity
3 = 1 x 2
• activity
• category
4
AVERAGE SECTION SIZE
• activity
5
Min^m size
Max^m size
Max^m number
6
NUMBER OF SECTIONS
6 = 3 / 4 subject to 5
• activity
7
CONTACT-HOURS
• activity
8
ACTIVITIES
• cost center
• type of activity
9
TEACHING WEEKLY CONTACT-HOURS GENERATED
9 = 6 x 7
using 8
• type of activity
• cc
10
RESOURCE REQUIREMENT
• activity
• type of resource
11
SPACE POLICIES
12
SPACE CO-HOURS required
• space category
• section
• cc
TEACHING SPACE CONTACT-HOURS required
13 = 9 x 10 x
using 11
• space category
• cc

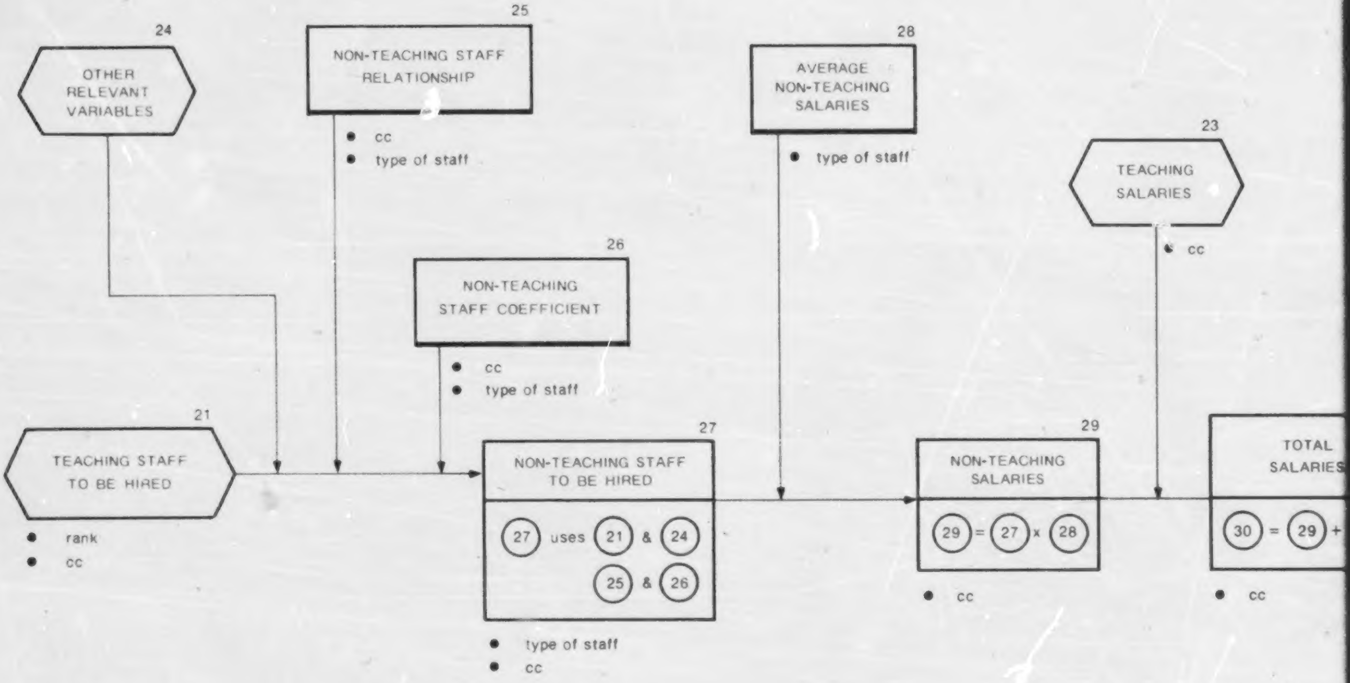
Key to Acronyms : cc = cost center
Co-Hrs = contact-hours


10
RESOURCE REQUIREMENT
activity
type of resource
11
SPACE POLICIES
5
Min^m size
Max^m size
Max^m number
8
ACTIVITIES
cost center
type of activity
12
SPACE CO-HOURS required
space category
section
cc
4
AVERAGE SECTION SIZE
activity
7
CONTACT-HOURS
activity
3
STUDENT ENROLLMENT in each activity
= 1 x 2
activity
category
6
NUMBER OF SECTIONS
6 = 3 / 4 to 5 subject
activity
9
TEACHING WEEKLY CONTACT-HOURS GENERATED
9 = 6 x 7
using 8
type of activity
cc
13
TEACHING SPACE CONTACT-HOURS required
13 = 9 x 10 x 12
using 11
space category
cc
-hours


STAFFING POLICIES
1. Contract length
2. Sabbatical
3. Weekly availability
4. Staffing unit weight for each activity type
5. Teaching staff
6. Promotion
7. Rank substitution
● rank
● cc
STAFFING POLICIES
1. Hiring criterion
2. Rank distribution
3. Non-teaching requirements promotion substitution
● rank
● cc
16
NON-TEACHING DUTIES LOAD
● rank
● cc
17
TEACHING LOAD IN STAFFING UNITS
● rank
● cc
20
STAFF INVENTORIES AND AVAILABILITIES
● rank
● cc
22
AVERAGE TEACHING STAFF SALARIES
● rank
● cc
● type
9
TEACHING STAFF CONTACT HOURS
● type of activity
● cost center
18
TEACHING STAFF REQUIRED
18 = 9 + 16 17
using 15
● rank
● cc
21
TEACHING STAFF TO BE HIRED
21 = 20 - 18
using 19
● rank
● cc
● type
23
TEACHING SALARIES
23 = 21 x 22
● cc

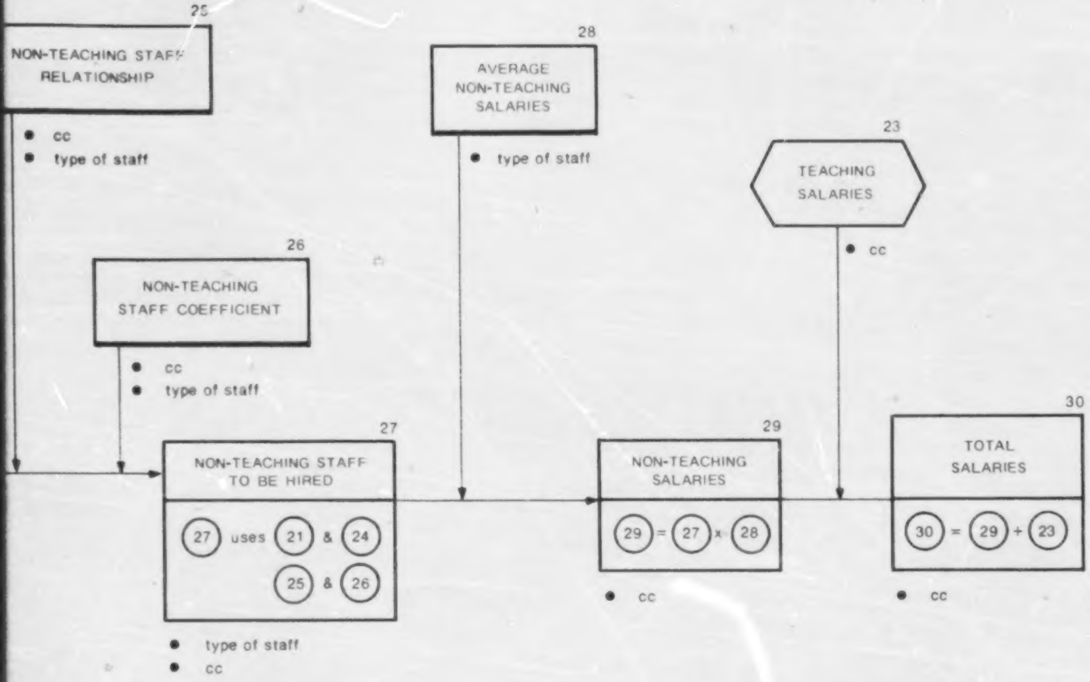
(For Salaries)

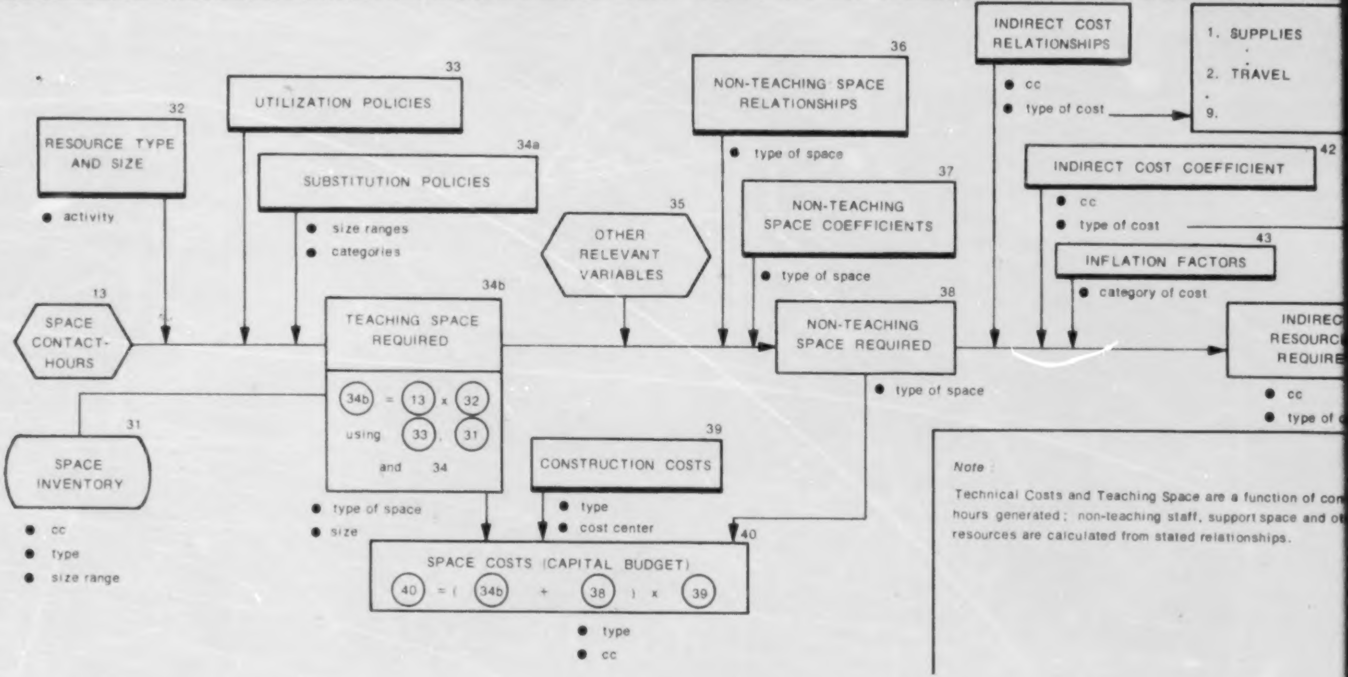
Page 2 of 4


24
OTHER RELEVANT VARIABLES
25
NON-TEACHING STAFF RELATIONSHIP
● cc
● type of staff
28
AVERAGE NON-TEACHING SALARIES
● type of staff
23
TEACHING SALARIES
● cc
26
NON-TEACHING STAFF COEFFICIENT
● cc
● type of staff
21
TEACHING STAFF TO BE HIRED
● rank
● cc
27
NON-TEACHING STAFF TO BE HIRED
(27) uses (21) & (24)
(25) & (26)
● type of staff
● cc
29
NON-TEACHING SALARIES
(29) = (27) x (28)
● cc
TOTAL SALARIES
(30) = (29) +
● cc

(For Salaries)

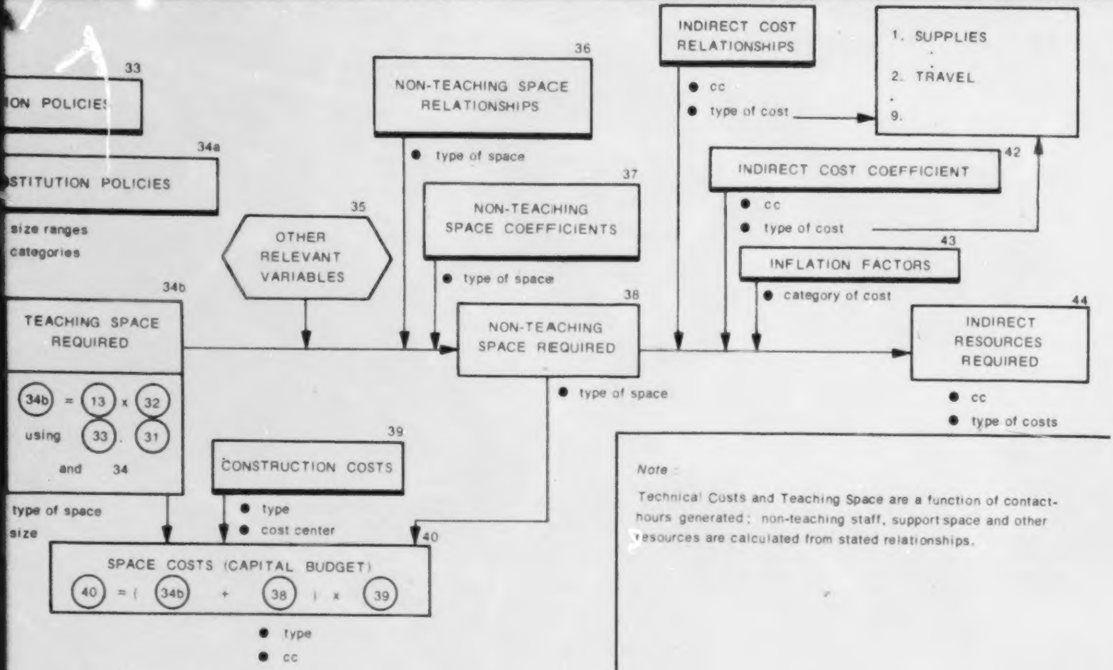
Page 2 of 4


25
NON-TEACHING STAFF RELATIONSHIP
● cc
● type of staff
26
NON-TEACHING STAFF COEFFICIENT
● cc
● type of staff
27
NON-TEACHING STAFF TO BE HIRED
(27) uses (21) & (24)
(25) & (26)
● type of staff
● cc
28
AVERAGE NON-TEACHING SALARIES
● type of staff
29
NON-TEACHING SALARIES
(29) = (27) x (28)
● cc
23
TEACHING SALARIES
● cc
30
TOTAL SALARIES
(30) = (29) + (23)
● cc


32
RESOURCE TYPE AND SIZE
activity
33
UTILIZATION POLICIES
34a
SUBSTITUTION POLICIES
size ranges
categories
13
SPACE CONTACT-HOURS
34b
TEACHING SPACE REQUIRED
34b = 13 x 32
using 33, 31
and 34
type of space
size
31
SPACE INVENTORY
cc
type
size range
35
OTHER RELEVANT VARIABLES
39
CONSTRUCTION COSTS
type
cost center
40
SPACE COSTS (CAPITAL BUDGET)
40 = (34b + 38) x 39
type
cc
36
NON-TEACHING SPACE RELATIONSHIPS
type of space
37
NON-TEACHING SPACE COEFFICIENTS
type of space
38
NON-TEACHING SPACE REQUIRED
type of space
INDIRECT COST RELATIONSHIPS
cc
type of cost
1. SUPPLIES
2. TRAVEL
9.
42
INDIRECT COST COEFFICIENT
cc
type of cost
43
INFLATION FACTORS
category of cost
INDIREC
RESOURC
REQUIRE
cc
type of c

Note :

Technical Costs and Teaching Space are a function of con hours generated; non-teaching staff, support space and ot resources are calculated from stated relationships.

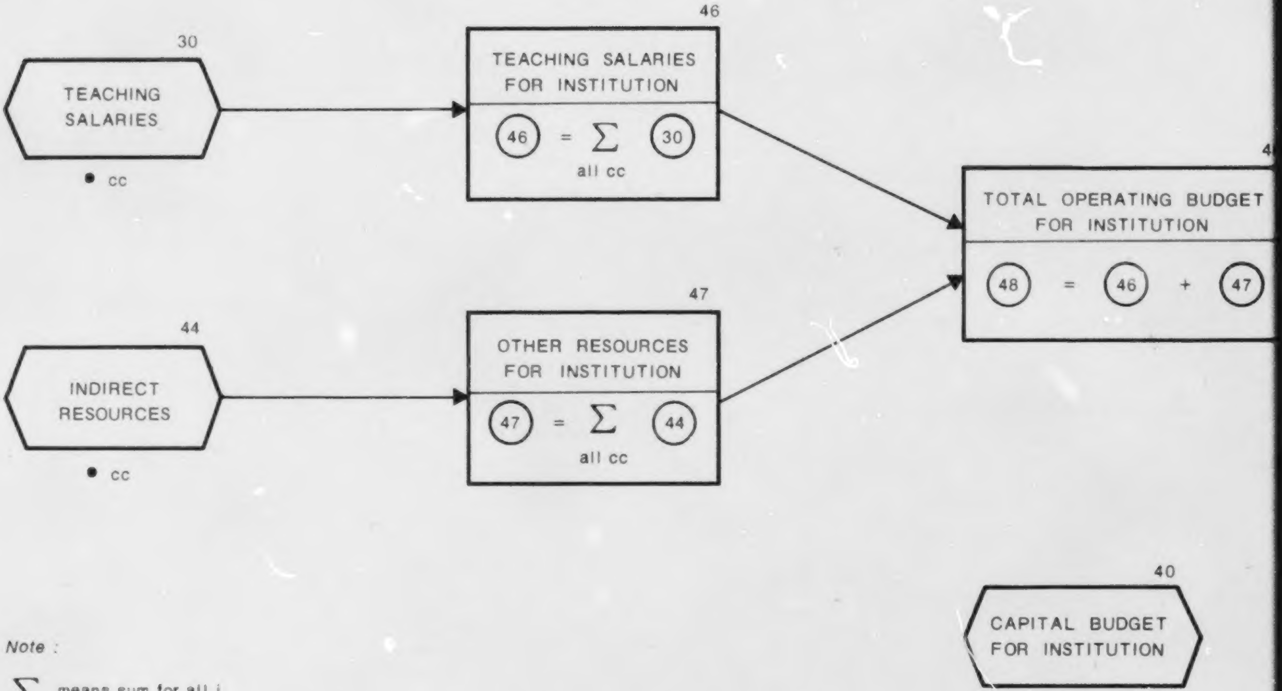

33
ION POLICIE
34a
STITUTION POLICIES
size ranges
categories
34b
TEACHING SPACE REQUIRED
34b = 13 x 32
using 33, 31
and 34
type of space
size
35
OTHER RELEVANT VARIABLES
36
NON-TEACHING SPACE RELATIONSHIPS
● type of space
37
NON-TEACHING SPACE COEFFICIENTS
● type of space
38
NON-TEACHING SPACE REQUIRED
● type of space
39
CONSTRUCTION COSTS
● type
● cost center
40
SPACE COSTS (CAPITAL BUDGET)
40 = (34b + 38) x 39
● type
● cc
INDIRECT COST RELATIONSHIPS
● cc
● type of cost
1. SUPPLIES
2. TRAVEL
9.
42
INDIRECT COST COEFFICIENT
● cc
● type of cost
43
INFLATION FACTORS
● category of cost
44
INDIRECT RESOURCES REQUIRED
● cc
● type of costs

Note :

Technical Costs and Teaching Space are a function of contact-hours generated ; non-teaching staff, support space and other resources are calculated from stated relationships.

RESOURCE CONVERTER

(Page 4 of 4)

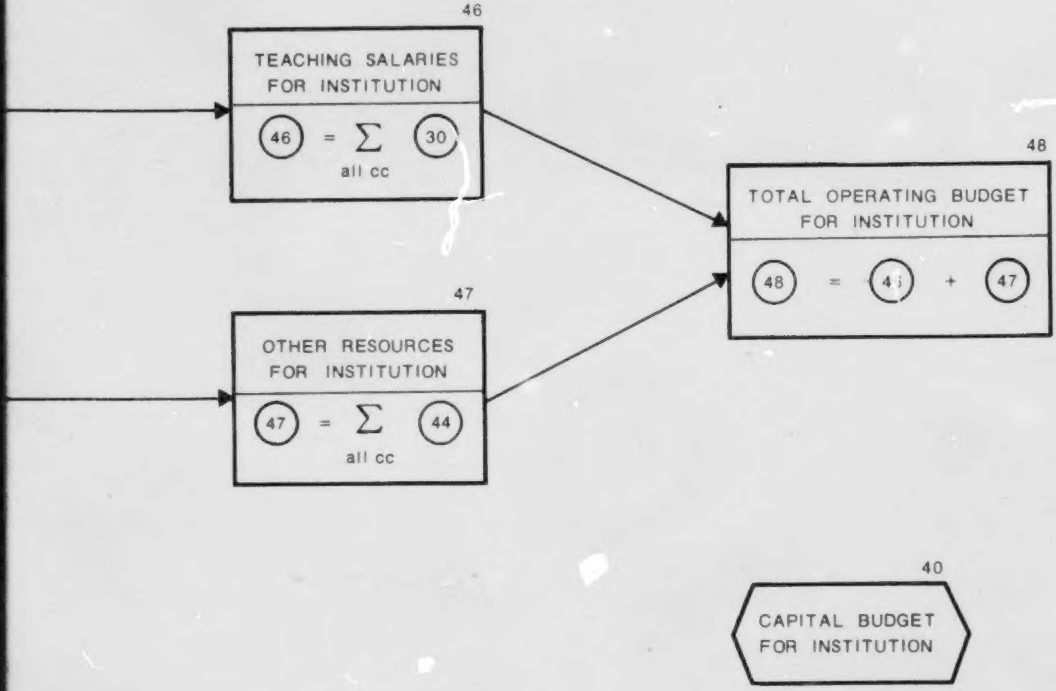

30
TEACHING SALARIES
• cc
46
TEACHING SALARIES FOR INSTITUTION
46 = Σ 30
all cc
44
INDIRECT RESOURCES
• cc
47
OTHER RESOURCES FOR INSTITUTION
47 = Σ 44
all cc
TOTAL OPERATING BUDGET FOR INSTITUTION
48 = 46 + 47
40
CAPITAL BUDGET FOR INSTITUTION

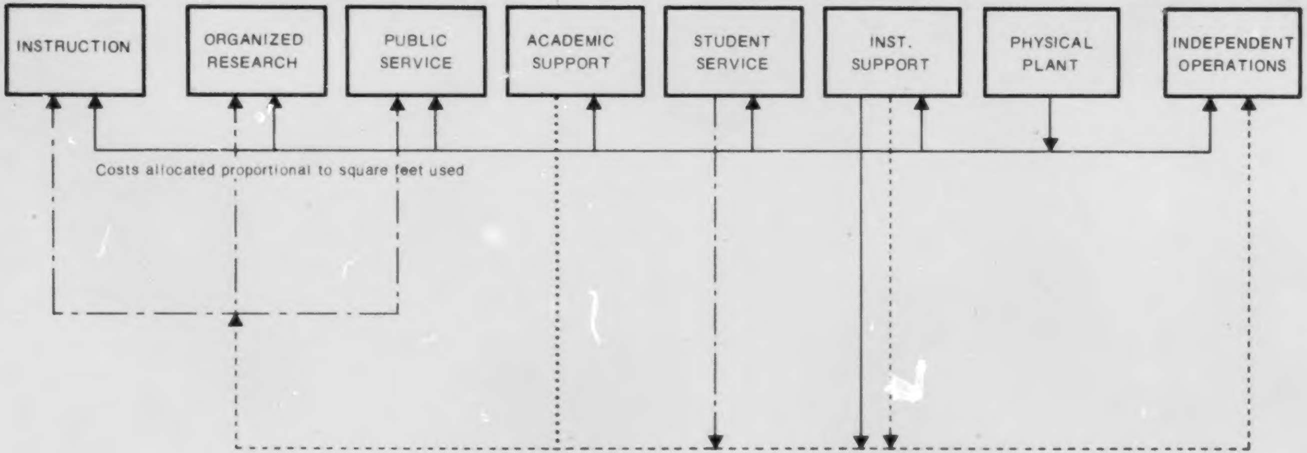
Note :

Σ means sum for all i

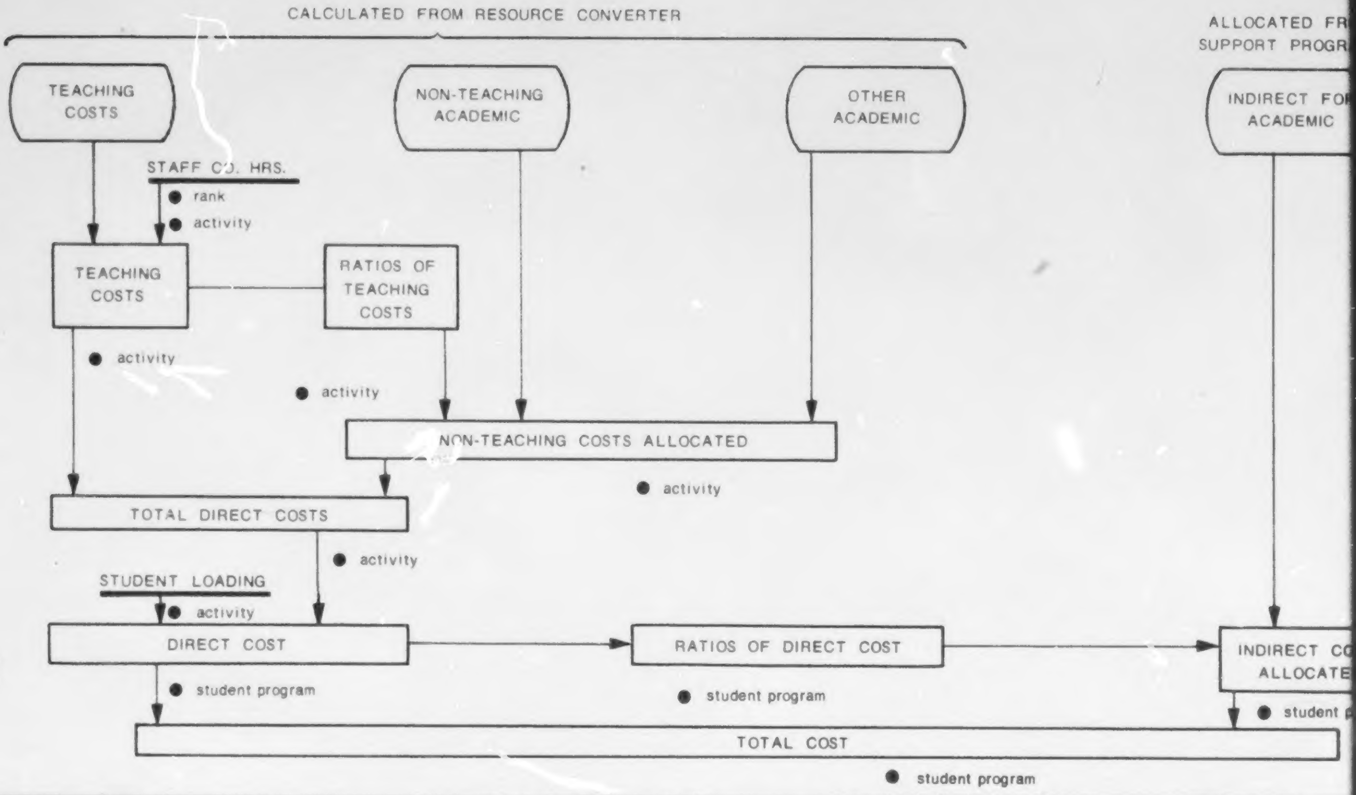
RESOURCE CONVERTER

(Page 4 of 4)

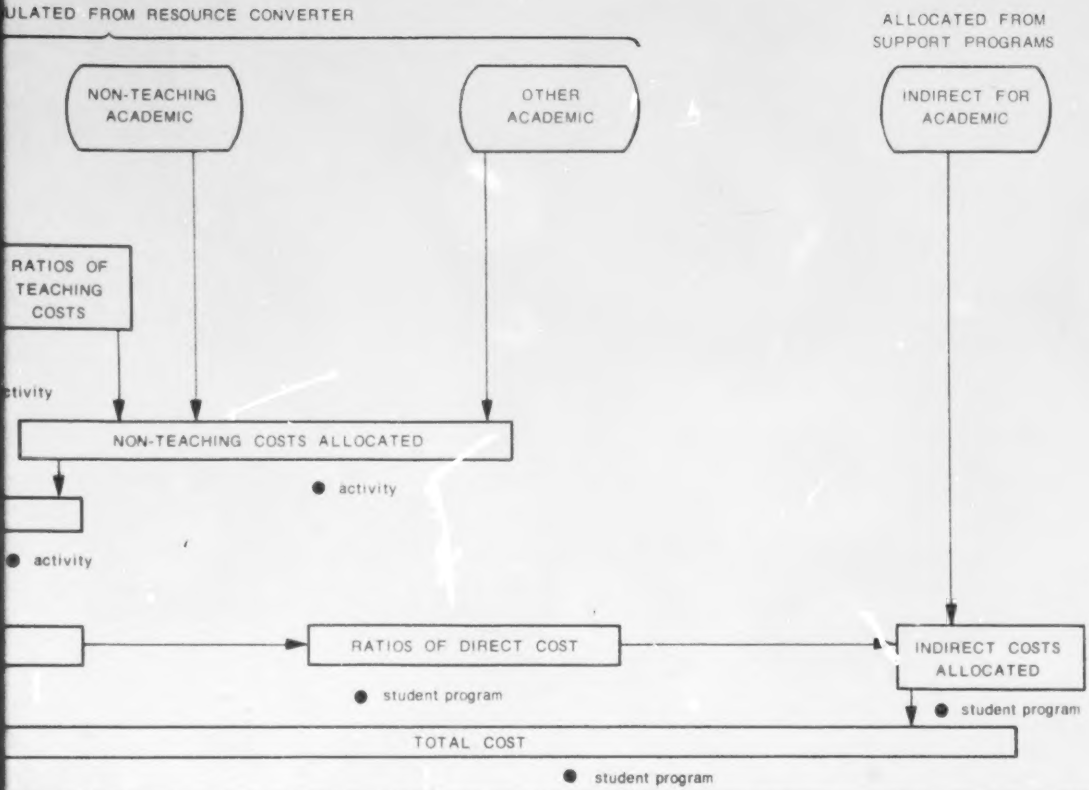

46
TEACHING SALARIES FOR INSTITUTION
(46) = Σ all cc (30)
47
OTHER RESOURCES FOR INSTITUTION
(47) = Σ all cc (44)
48
TOTAL OPERATING BUDGET FOR INSTITUTION
(48) = (46) + (47)
40
CAPITAL BUDGET FOR INSTITUTION



INSTRUCTION
ORGANIZED RESEARCH
PUBLIC SERVICE
ACADEMIC SUPPORT
STUDENT SERVICE
INST. SUPPORT
PHYSICAL PLANT
INDEPENDENT OPERATIONS
Costs allocated proportional to square feet used


CALCULATED FROM RESOURCE CONVERTER
ALLOCATED FR
SUPPORT PROGR
TEACHING COSTS
NON-TEACHING ACADEMIC
OTHER ACADEMIC
INDIRECT FO
ACADEMIC
STAFF CO. HRS.
● rank
● activity
TEACHING COSTS
RATIOS OF TEACHING COSTS
● activity
● activity
NON-TEACHING COSTS ALLOCATED
● activity
TOTAL DIRECT COSTS
● activity
STUDENT LOADING
● activity
DIRECT COST
RATIOS OF DIRECT COST
INDIRECT CO
ALLOCATE
● student program
● student program
● student p
TOTAL COST
● student program

(Page 2 of 2)


ULATED FROM RESOURCE CONVERTER
ALLOCATED FROM SUPPORT PROGRAMS
NON-TEACHING ACADEMIC
OTHER ACADEMIC
INDIRECT FOR ACADEMIC
RATIOS OF TEACHING COSTS
tivity
NON-TEACHING COSTS ALLOCATED
● activity
● activity
RATIOS OF DIRECT COST
● student program
INDIRECT COSTS ALLOCATED
● student program
TOTAL COST
● student program

Contents to Exercises

Exercise
(Problem)

1. Determine Student Loading
2. Determine Number of Sections
3. Determine Full-Time Equivalent Required
4. Determine Salaries
5. Calculate Construction Costs
6. Determine Supply Costs
7. Calculate Cost per Student Contact Hour
8. Calculate Program Direct Costs
9. Calculate Total Program Unit Costs
10. Calculate Student Loading using Participation Rates

PROBLEMS ON USING CAMPUS/COLORADO

Problem#1: Determine Student Loading for ES Cost Center

Consider an institution that is considering adding a new cost-center teaching Environmental studies (ES).

Determine the student load that would be generated by the ES cost center given that, the students in programs who will take courses in ES and their loading are shown below.

For student program 1, the number of students estimated for taking courses are as follows:

English	101	(3)	=	30
Physics	100	(3)	=	20
Biology	102	(3)	=	10
History	105	(4)	=	30
Math	110	(3)	=	10
Math	110L	(1)	=	10
ES	120	(3)	=	20
ES	120L	(1)	=	30

The average student in student program 2 takes the following courses:

English	101	(3)
Zoology	150	(3)
ES	120	(3)
ES	120L	(1)
ES	120R	(1)

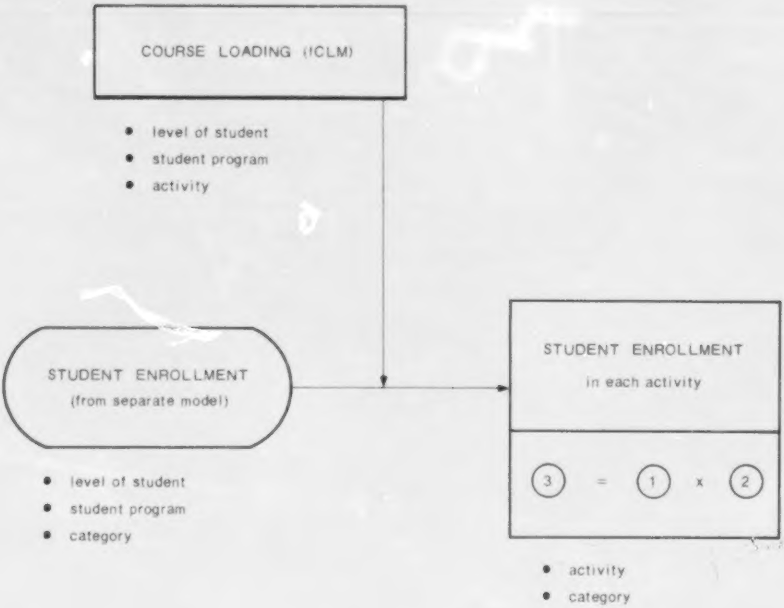
There is a 200 student enrollment estimated for student program # 2.

For student program # 3, the student enrollment is estimated as follows:

English	101	(3)	=	100
History	105	(4)	=	100
Zoology	150	(3)	=	100
ES	120	(3)	=	100
ES	120L	(1)	=	60
ES	120R	(1)	=	40

Note: The number in parenthesis is the contact hour load for the preceding activity identification.

LOGIC CHART FOR PROBLEM # 1


COURSE LOADING (ICLM)
level of student
student program
activity
STUDENT ENROLLMENT
(from separate model)
level of student
student program
category
STUDENT ENROLLMENT
in each activity
③ = ① x ②
activity
category

Worksheet for Solution # 1

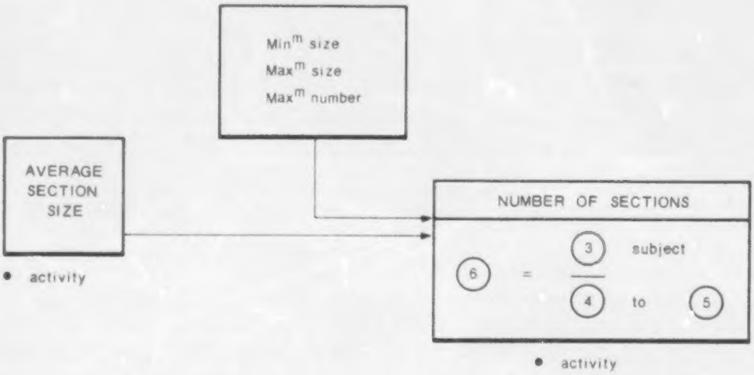
	Student programs			Total Student Enrollment in each activity
	#1	#2	#3	
Total student-activity enrollment for all courses				
Total student-activity enrollment for ES				

Problem # 2: Determine number of sections

Calculate the number of sections for problem # 1, for cost center ES, given the following planning variables:

	Lecture	Lab	Recitation
Average section size	25	50	30
Minimum section size	22	40	25
Maximum section size	60	55	40
Maximum sections	12	6	10

APPROPRIATE LOGIC CHART :


Min^m size
Max^m size
Max^m number
AVERAGE SECTION SIZE
• activity
NUMBER OF SECTIONS
⑥ = ③ / ④ subject to ⑤
• activity

Worksheet for Solution # 2

	Lec	Lab	Rec	Remarks
1. No. of students	320			From solution # 1
2. Average Section Size	25			Planning variable (Pr # 2)
3. No. of Sections (preliminary estimate)				③ = ① / ②
4. Students left over				④ = ① - ② x ③
5a. No. of sections				Manipulation of number of sections and sizes to meet planning factor constraints given in Problem # 2
5b. Size of each section in (5a)				
Combination to be used if necessary				
6a. No. of Sections				
6b. Size of sections in (6a)				
7. Total No. of Sections				⑦ = (5a) + (6a)
8. Total No. of Students				⑧ = [(5a) x (5b)] + [(6a) x (6b)] ⑧ = ①
Check				
9. Maximum size	60			⑨ must be > (5b) or (6b)
10. Minimum size	22			⑩ must be ≤ (5b) or (6b)
11. Maximum No. of Sections	12			⑪ must be ≥ ⑦

Notes > means greater than

< means less than

Solution # 2

	Lec	Lab	Rec	Remarks
1. No. of students	320	290	240	From solution # 1
2. Average Section Size	25	50	30	Planning variable (Pr # 2)
3. No. of Sections (preliminary estimate)	12	5	8	③ = ① / ②
4. Students left over	20	40		④ = ① - ② x ③
5a. No. of sections	11	5	8	Manipulation of number of sections and sizes to meet planning factor constraints given in Problem # 2
5b. Size of each section in (5a)	25	50	30	
Combination to be used if necessary				
6a. No. of Sections	1	1	---	
6b. Size of sections in (6a)	45	40	---	
7. Total No. of Sections	12	6	8	⑦ = (5a) + (6a)
8. Total No. of Students	320	290	240	⑧ = [(5a) x (5b)] + [(6a) x (6b)] ⑧ = ①
Check				
9. Maximum size	60	55	40	⑨ must be > (5b) or (6b)
10. Minimum size	22	40	25	⑩ must be ≤ (5b) or (6b)
11. Maximum No. of Sections	12	6	10	⑪ must be ≥ ⑦

Notes : > means greater than

< means less than

Problem#5: Determine full-time equivalent [illegible] center

Assume data to be as given with previous problem.

For the ES cost center, the planning variables have been estimated as follows:

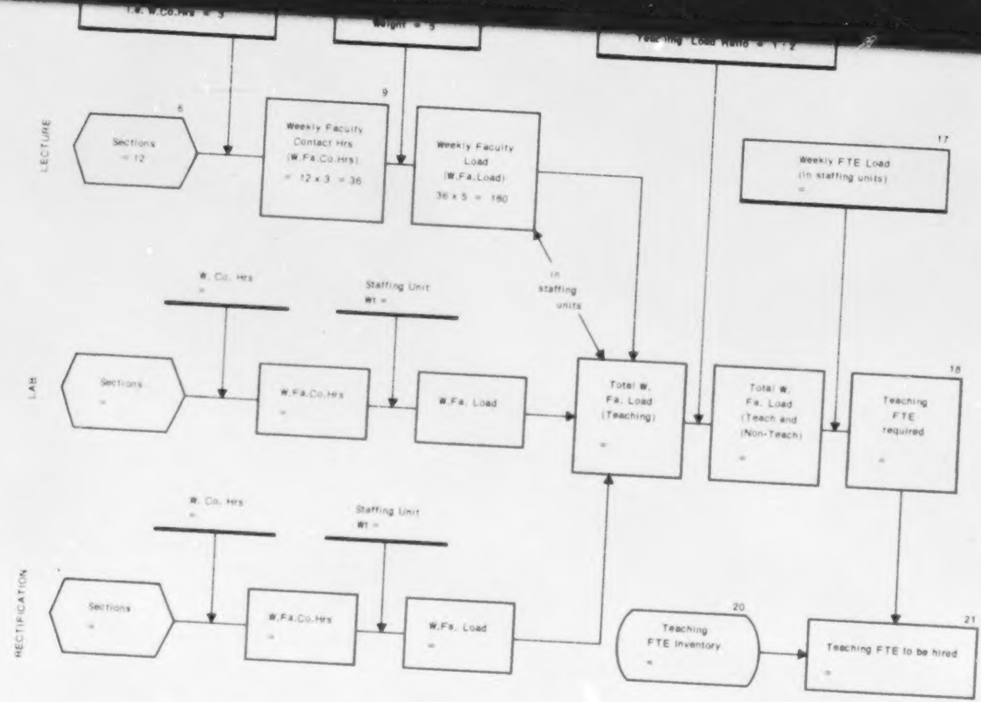
Staffing unit weights:

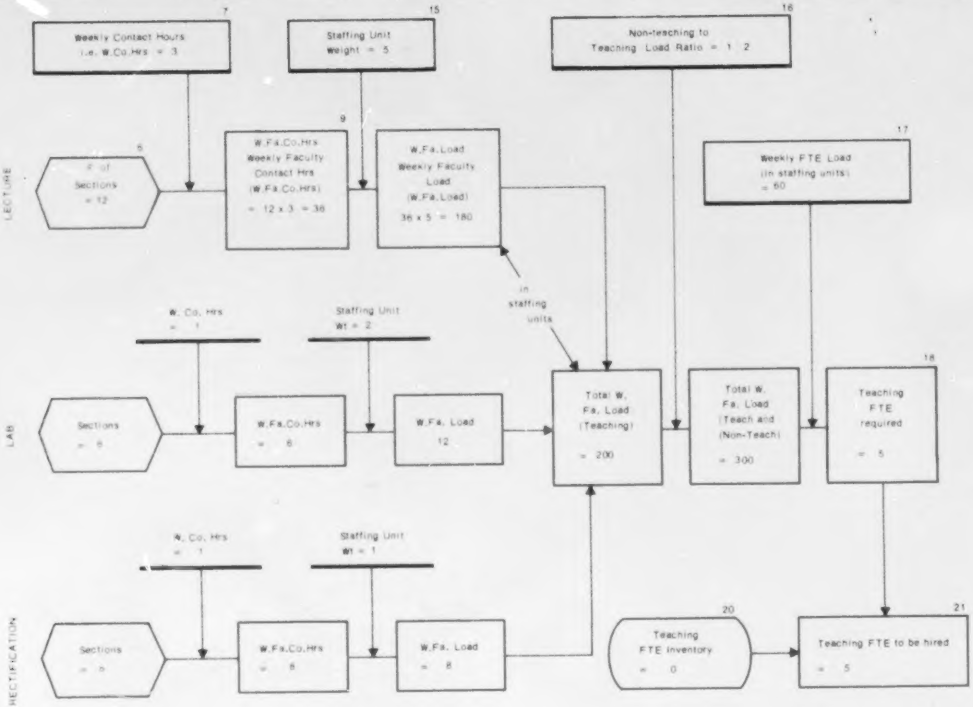
Lecture = 5
Lab = 2
Recitation = 1

Total staffing units per FTE = 60

Av. Research load per FTE	=	10	i.e.	1/6
Av. Administrative load per FTE	=	10	i.e.	1/6
Av. Teaching load	=	40	i.e.	2/3

Note: ES is a new cost center.


W.Co.Hrs = 3
Weight = 5
Teaching Load Ratio = 1 : 2
LECTURE
6
Sections
= 12
9
Weekly Faculty
Contact Hrs
(W.Fa.Co.Hrs)
= 12 x 3 = 36
Weekly Faculty
Load
(W.Fa.Load)
36 x 5 = 180
17
Weekly FTE Load
(in staffing units)
=
in
staffing
units
LAB
W. Co. Hrs
=
Staffing Unit
Wt =
Sections
=
W.Fa.Co.Hrs
=
W.Fa. Load
Total W.
Fa. Load
(Teaching)
=
Total W.
Fa. Load
(Teach and
Non-Teach)
=
18
Teaching
FTE
required
=
RECTIFICATION
W. Co. Hrs
=
Staffing Unit
Wt =
Sections
=
W.Fa.Co.Hrs
=
W.Fa. Load
=
20
Teaching
FTE Inventory
=
21
Teaching FTE to be hired
=


7
Weekly Contact Hours
i.e. W.Co.Hrs = 3
15
Staffing Unit
Weight = 5
16
Non-teaching to
Teaching Load Ratio = 1 : 2
LECTURE
6
# of
Sections
= 12
9
W.Fa.Co.Hrs
Weekly Faculty
Contact Hrs
(W.Fa.Co.Hrs)
= 12 x 3 = 36
W.Fa.Load
Weekly Faculty
Load
(W.Fa.Load)
36 x 5 = 180
17
Weekly FTE Load
(in staffing units)
= 60
in
staffing
units
LAB
W. Co. Hrs
= 1
Staffing Unit
Wt = 2
Sections
= 6
W.Fa.Co.Hrs
= 6
W.Fa. Load
12
Total W.
Fa. Load
(Teaching)
= 200
Total W.
Fa. Load
(Teach and
(Non-Teach)
= 300
18
Teaching
FTE
required
= 5
RECTIFICATION
W. Co. Hrs
= 1
Staffing Unit
Wt = 1
Sections
= 8
W.Fa.Co.Hrs
= 8
W.Fa. Load
= 8
20
Teaching
FTE Inventory
= 0
21
Teaching FTE to be hired
= 5

	Lec	Lab	Rec	Remarks
1. Number of Sections	12	6	8	From solution # 2
2. Weekly Co.Hr./section	3	1	1	From Prob. # 1 data
3. Weekly Fac.Co.Hrs.	36	6	8	③ = ① x ②
4. Staff. unit weights	5	2	1	Planning variables
5. Weighted staff load	180	12	8	⑤ = ③ x ④
6. Total staff teach. load		200		⑥ = Σ ⑤
7. Non-teaching load		100		Planning variable
8. Total staff load		300		⑧ = ⑥ + ⑦
9. Av. FTE load		60		Planning variable
10. FTE required		5		⑩ = ⑧ / ⑨
11. Inventory		0		Given in Prob. # 1
12. FTE to be hired		5		⑫ = ⑩ - ⑪

Problem#4: Determine Salaries

Assuming the data for the previous problems, determine the salaries for cost center ES given the following planning variables:

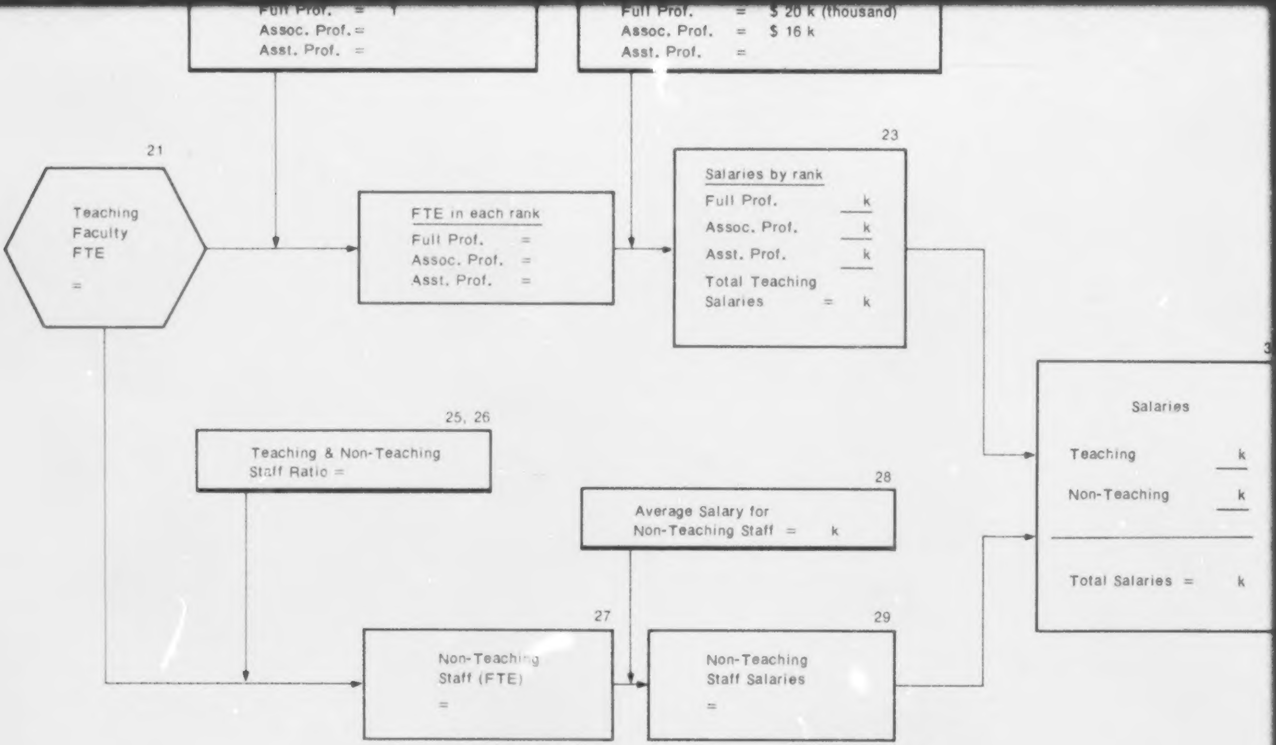
Rank distribution:

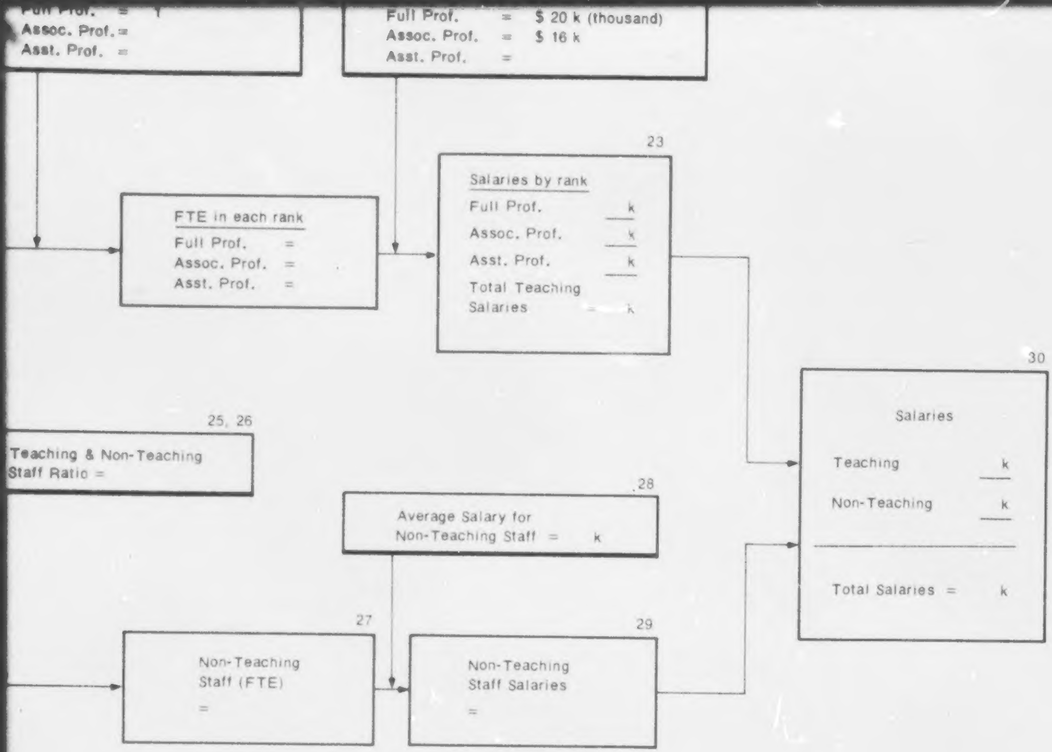
Full professor	1
Assoc. professor	2
Asst. professor	2

Non-teaching staff = $\frac{4}{5}$ Teaching Staff

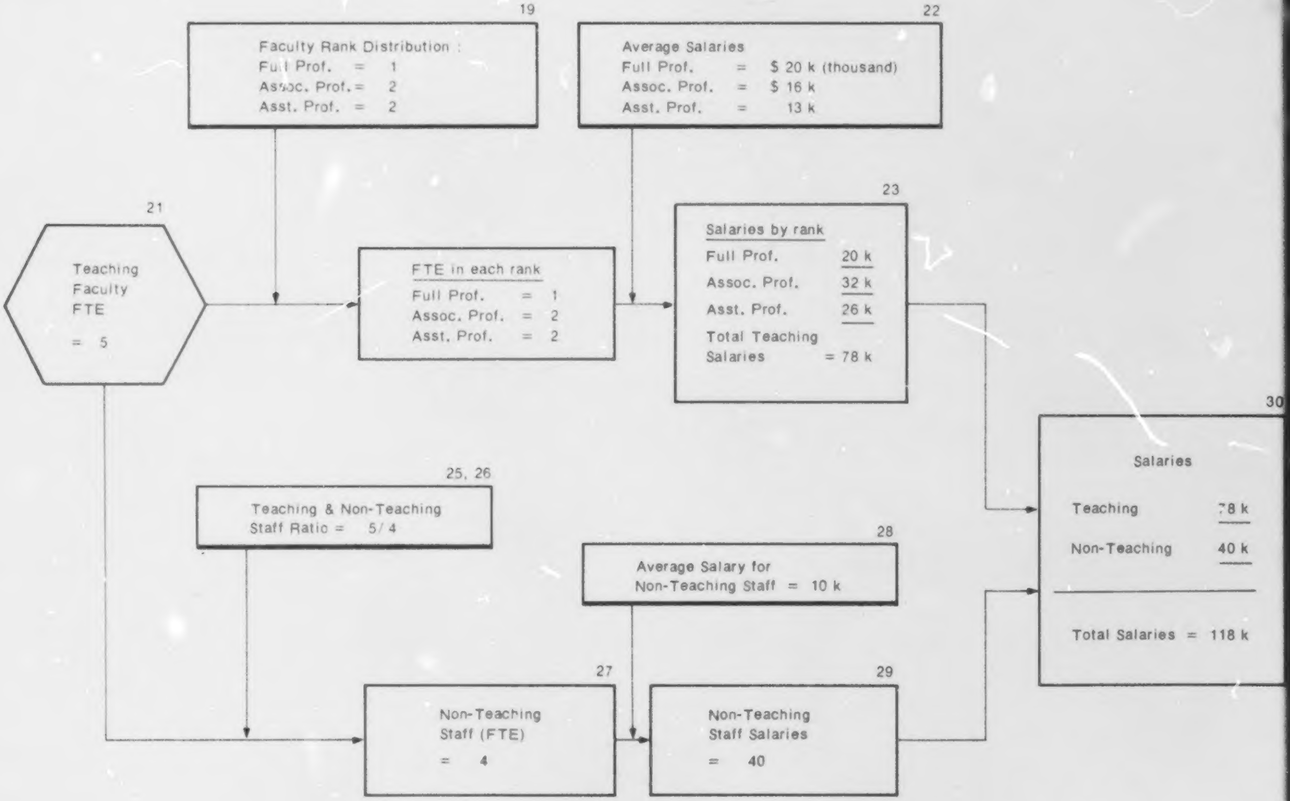
Average salaries:

Full professor = $20,000
Assoc. professor = $16,000
Asst. professor = $13,000
Non-teach. staff = $10,000


Full Prof. = 1
Assoc. Prof. =
Asst. Prof. =
Full Prof. = $ 20 k (thousand)
Assoc. Prof. = $ 16 k
Asst. Prof. =
21
Teaching
Faculty
FTE
=
FTE in each rank
Full Prof. =
Assoc. Prof. =
Asst. Prof. =
23
Salaries by rank
Full Prof. k
Assoc. Prof. k
Asst. Prof. k
Total Teaching
Salaries = k
25, 26
Teaching & Non-Teaching
Staff Ratio =
28
Average Salary for
Non-Teaching Staff = k
27
Non-Teaching
Staff (FTE)
=
29
Non-Teaching
Staff Salaries
=
Salaries
Teaching k
Non-Teaching k
Total Salaries = k


Full Prof. = 1
Assoc. Prof. =
Asst. Prof. =
Full Prof. = $ 20 k (thousand)
Assoc. Prof. = $ 16 k
Asst. Prof. =
23
Salaries by rank
Full Prof. k
Assoc. Prof. k
Asst. Prof. k
Total Teaching Salaries = k
FTE in each rank
Full Prof. =
Assoc. Prof. =
Asst. Prof. =
30
Salaries
Teaching k
Non-Teaching k
Total Salaries = k
25, 26
Teaching & Non-Teaching Staff Ratio =
28
Average Salary for Non-Teaching Staff = k
27
Non-Teaching Staff (FTE) =
29
Non-Teaching Staff Salaries =

SOLUTION # 4



19
Faculty Rank Distribution :
Full Prof. = 1
Assoc. Prof. = 2
Asst. Prof. = 2

22
Average Salaries
Full Prof. = $ 20 k (thousand)
Assoc. Prof. = $ 16 k
Asst. Prof. = 13 k

21
Teaching Faculty FTE
= 5

FTE in each rank
Full Prof. = 1
Assoc. Prof. = 2
Asst. Prof. = 2

23
Salaries by rank
Full Prof. 20 k
Assoc. Prof. 32 k
Asst. Prof. 26 k
Total Teaching Salaries = 78 k

25, 26
Teaching & Non-Teaching Staff Ratio = 5/ 4

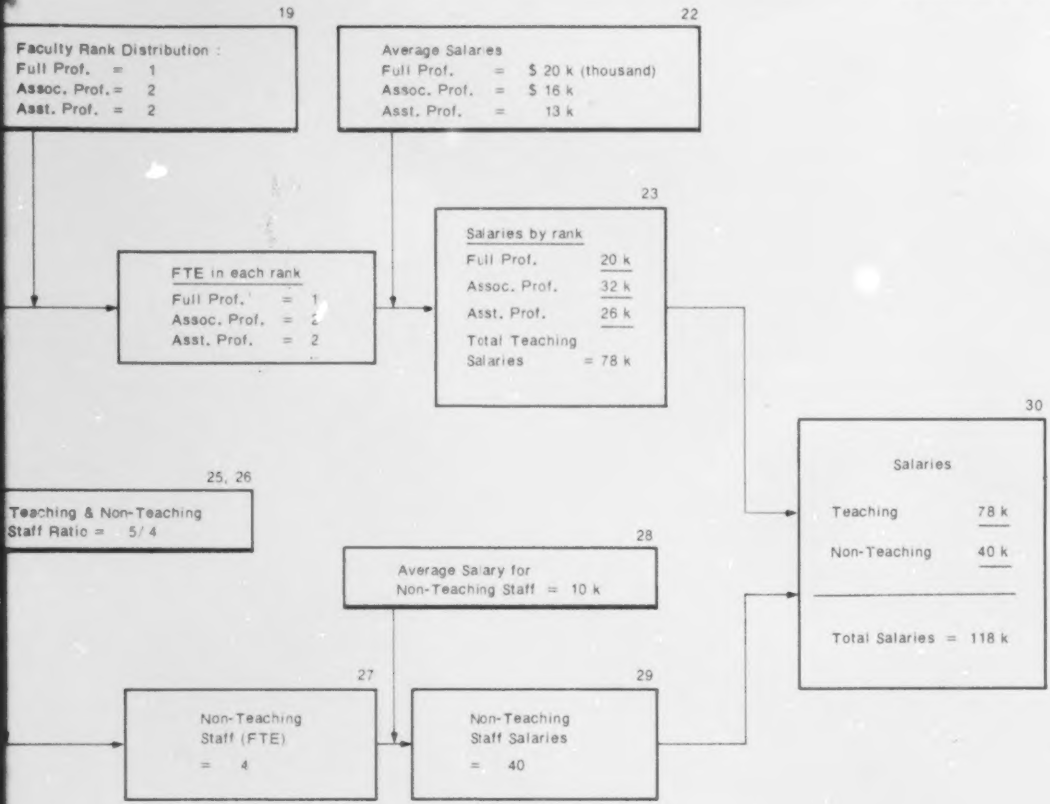
28
Average Salary for Non-Teaching Staff = 10 k

27
Non-Teaching Staff (FTE)
= 4

29
Non-Teaching Staff Salaries
= 40

30
Salaries
Teaching 78 k
Non-Teaching 40 k
Total Salaries = 118 k

SOLUTION # 4



19

Faculty Rank Distribution :
Full Prof. = 1
Assoc. Prof. = 2
Asst. Prof. = 2

22

Average Salaries
Full Prof. = $ 20 k (thousand)
Assoc. Prof. = $ 16 k
Asst. Prof. = 13 k

FTE in each rank
Full Prof. = 1
Assoc. Prof. = 2
Asst. Prof. = 2

23

Salaries by rank
Full Prof. 20 k
Assoc. Prof. 32 k
Asst. Prof. 26 k
Total Teaching Salaries = 78 k

25, 26

Teaching & Non-Teaching Staff Ratio = 5/4

28

Average Salary for Non-Teaching Staff = 10 k

27

Non-Teaching Staff (FTE) = 4

29

Non-Teaching Staff Salaries = 40

30

Salaries
Teaching 78 k
Non-Teaching 40 k
Total Salaries = 118 k

Solution # 4

1. Teaching faculty	5	From solution # 3
2. Rank mix Full. Assoc. Asst.	1 : 2 : 2	Planning variable given
3. Rank mix	1 : 2 : 2	From ① & ②
4. Faculty salary sched.	20 : 16 : 13	Planning variable
5. Salaries		From ③ & ④
Full Prof.	$ 20,000	
Assoc. Prof.	$ 32,000	
Asst. Prof.	$ 26,000	
6. Total teaching salaries	$ 78,000	⑥ = Σ ⑤
7. Non-teaching / teach. staff	4 : 5	Planning variable given
8. Teaching staff	5	From solution # 3
9. Non-teaching staff	4	From ⑦ = ⑧
10. Non-teaching av. salary	$ 10,000	Planning variable
11. Non-teaching salaries	$ 40,000	⑪ = ⑨ x ⑩
12. Total salaries	$ 118,000	⑫ = ⑥ + ⑪

Problem#5: Calculate Construction Costs

Calculate the construction costs for the ES department for classroom construction using data developed previously and using the following additional factors:

Weekly Room hours = Weekly Faculty Contact-Hours

Room utilization = 33 hours/week/room

Substitution policy = Rooms are compatible downwards up to one larger room size. i.e. a room of 50 can be used for a class of 30

Inventory = Assume that the college of ES has the following surpluses that can be used by ES

Size	
30	0
50	1
70	2

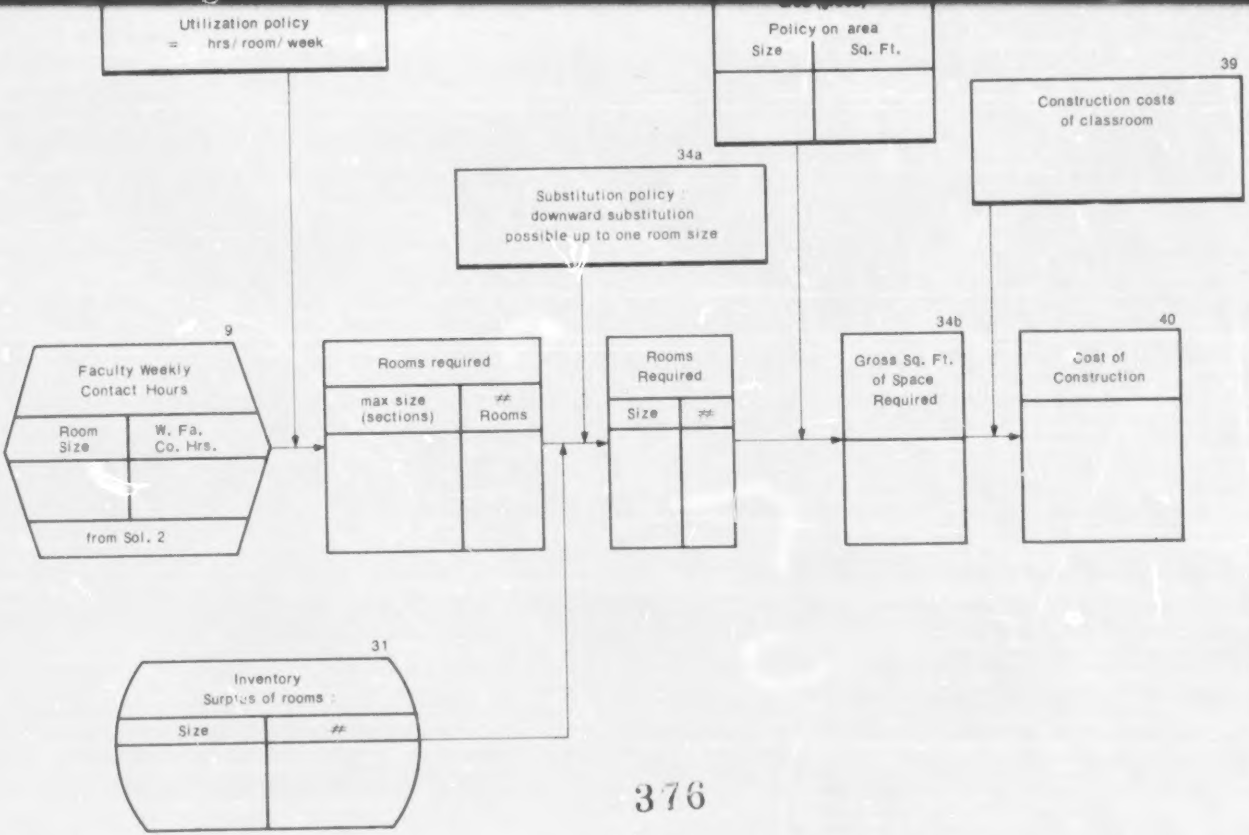
Policy on room size

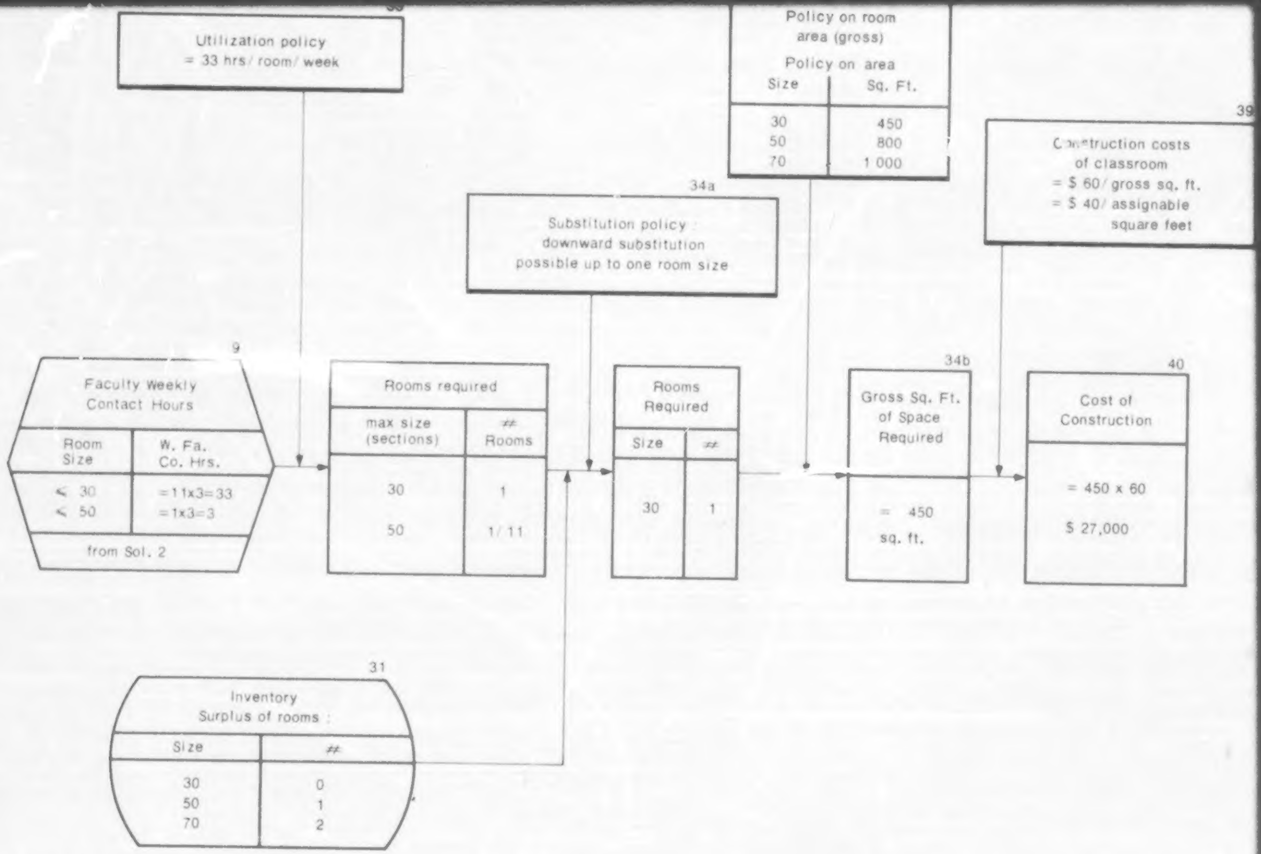
stations	Gross sq.ft.
10	200
20	360
30	450
50	800
70	1,000

Construction costs for classroom for ES = $60/gross sq.ft.

Notes:

1. This problem is concerned only with classroom space for lectures only.
2. Assume that for the ES department, the credit-hour load = contact-hour load.


Utilization policy
= hrs/ room/ week
Policy on area
Size
Sq. Ft.
39
Construction costs of classroom
34a
Substitution policy : downward substitution possible up to one room size
9
Faculty Weekly Contact Hours
Room Size
W. Fa. Co. Hrs.
from Sol. 2
Rooms required
max size (sections)
# Rooms
Rooms Required
Size
#
34b
Gross Sq. Ft. of Space Required
40
Cost of Construction
31
Inventory Surplus of rooms :
Size
#



33
Utilization policy
= 33 hrs/ room/ week
Policy on room
area (gross)
Policy on area
Size | Sq. Ft.
30 | 450
50 | 800
70 | 1 000
39
Construction costs
of classroom
= $ 60/ gross sq. ft.
= $ 40/ assignable
square feet
34a
Substitution policy :
downward substitution
possible up to one room size
9
Faculty Weekly
Contact Hours
Room Size | W. Fa. Co. Hrs.
≤ 30 | =11x3=33
≤ 50 | =1x3=3
from Sol. 2
Rooms required
max size (sections) | ≠ Rooms
30 | 1
50 | 1/11
Rooms
Required
Size | ≠
30 | 1
34b
Gross Sq. Ft.
of Space
Required
= 450
sq. ft.
40
Cost of
Construction
= 450 x 60
$ 27,000
31
Inventory
Surplus of rooms :
Size | ≠
30 | 0
50 | 1
70 | 2

Problem #6: Determine the supply costs for ES

Determine the supply costs for ES cost center assuming the following cost relationships.

Supply cost =

$$a + b_1 x_1 + b_2 x_2 + b_3 x_3$$

where the planning factors are:

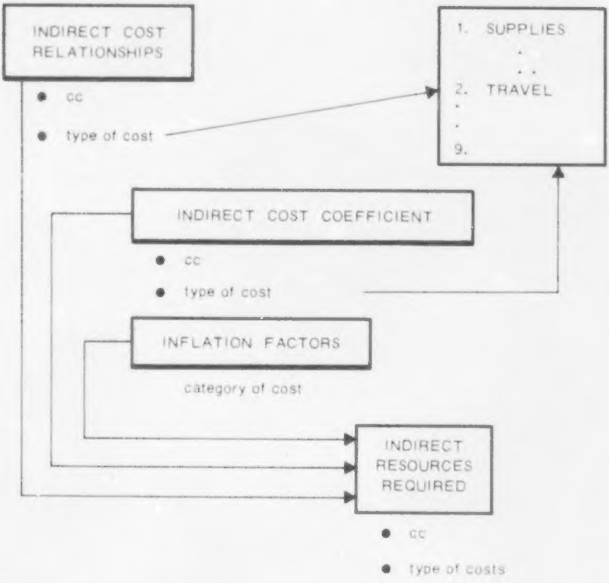
a = 2,800
b_1 = 2
b_2 = 10
b_3 = 500

and where x's are the basis:

x_1 = students taking courses (at all levels)
x_2 = weekly faculty contact-hour load (all types of activities)
x_3 = non-teaching staff FTE.

Assume data in past problems.

LOGIC DIAGRAM RELEVANT TO PROBLEM


INDIRECT COST RELATIONSHIPS
● cc
● type of cost
1. SUPPLIES
2. TRAVEL
9.
INDIRECT COST COEFFICIENT
● cc
● type of cost
INFLATION FACTORS
category of cost
INDIRECT RESOURCES REQUIRED
● cc
● type of costs

$$\text{Supplies Costs for ES Cost Center} = a + b_1 x_1 + b_2 x_2 + b_3 x_3$$

$$= \$ \quad + (\quad x \quad) + (\quad x \quad) + (\quad x \quad)$$

$$= \$ \quad + \quad + \quad +$$

$$= \$$$

Solution#6.

Supply cost for ES

$= a + b_1 x_1 + b_2 x_2 + b_3 x_3$

$$2800 + \underbrace{2 \times 850} + \underbrace{10 \times 50} + \underbrace{500 \times 4}$$

$$\begin{array}{cr} = & 2800 \\ & 1700 \\ & 500 \\ & \underline{2000} \\ = & 7000 \end{array}$$

(x_1 came from Solution 1 totals line
x_2 came from Solution 3 - 2nd column from left
x_3 came from Solution 4 - bottom line, middle)

Problem#7: Calculate Cost per Student Contact Hour

Find the cost per Student Contact Hour in the Cost Center ES, given the following planning factors concerning cost allocation.

Share of Indirect Cost to Academic Primary Program = 50%

Share of Indirect Costs to ES = 10% of all academic program

Furthermore, assume that:

1) Total Indirect Costs = $420,000
2) Support costs for ES other than supply costs = $3,000

Logic diagram appropriate to problem

See systems logic diagram for Resource Converter (p.3 of 4).

1. Determine Student Co. Hrs.

Total Student Co. Hrs. for ES = Students in ES 120 x Co.Hrs. for ES 120

+ Students in ES 120L x Co.Hrs. for ES 120L

+ Students in ES 120R x Co.Hrs. for ES 120R

= (x) + (x) + (x)

= ____________ Student Co.Hrs.

2. Indirect Cost to Academic Program = $

3. Share of Indirect Cost to ES =

= $ __________

Cost Components for ES

Salary Cost (solution #4) = $

Supply Costs (solution #6) = $

Other support costs (data) = $

Share of Indirect Cost (above) = $

Total Cost to ES = $

Cost per St.Co.Hr. in ES = $\frac{\text{Total Cost in ES}}{\text{Total St.Co.Hrs. in ES}}$

= ______________

= ______________ Answer

Determine Student Co.Hrs.

= students taking ES 120 x Co.Hrs.for ES 120
+ students taking ES 120L x Co.Hrs. for ES 120L
+ students taking ES 120R x Co.Hrs. for ES 120R
= 320 x 3 + 290 x 1 + 240 x 1
= 960 + 290 + 240
= $\underline{\underline{1490}}$

(Where student values came from Solution 1 last column 2. The Co. Hrs. came from Problem 1.)

Indirect cost to academic programs

= 50% x indirect cost
= 0.5 x 420,000
$210,000

Share of Indirect cost to ES	=	0.10 x 210,000	
	=	$21,000	
Salary cost for ES	=	118,000	(solution 4)
Non-supply cost for ES	=	3,000	(data)
Supply cost for ES	=	7,000	(solution 6)
Total Cost for ES	=	$149,000	

Cost per student Co. Hrs. in ES $= \dfrac{\text{Total Cost of ES}}{\text{Total Student Co.Hr. Generated on ES}}$

$= \dfrac{149,000}{1,490}$

= $100

Consider the student loading for 3 programs as solved for Problem # I. Add to this the students from all other programs taking the activities as shown below at freshmen level.

	# Students
Engl. 101	170
ES 120	180
Hist. 105	70
Zoo. 150	200
ES 120L	310
ES 120R	160

The direct cost of the activities are as follows:

Engl. 101	$4,000
ES 120	$3,000
Hist. 105	$2,200
Zoo. 150	$5,500
ES 120L	$8,000
ES 120R	$6,000

Calculate the direct cost of student program # 3 per student freshman.

Logic diagram appropriate to problem

See systems logic diagram of Resource Converter (p.4 of 4).

Problem 9: Calculate Total Program Unit Costs

Find the total cost for Program # 3 assuming that the indirect cost of program 3 is 1% of all the indirect cost of the Academic Programs.

Logic diagram appropriate to problem

See systems logic diagram of Resource Converter (p.4 of 4).

Worksheet # 8 for Calculating Program Direct Cost

	Programs				Total	% of 3 to Total	Cost of Activity	Share of
	1	2	3	All others				
Biology 102								
Engl. 101								
ES 120								
History 105								
Math. 110								
Phy. 100								
Zoology 150								
Math. 110L								
ES 120L								
ES 120R								

Total cost for student program # 3 =

Number of students: student program # 3
(from problem # 1) =

Cost/student in program # 3 =

	1	2	3	All others	Total	To Total	Activity	Share
Biology 102	10							
Engl. 101	30	200	100	170	500	.2	4000	800
ES 120	20	200	100	180	500	.2	3000	600
History 105	30		100	70	200	.5	2200	1100
Math. 110	10				10			
Phy. 100	20				20			
Zoology 150		200	100	200	500	.2	5600	1100
Math.110L	10				10			
ES 120L	30	200	60	311	600	.1	8000	800
ES 120R		200	40	160	400	.1	6000	600
								5000

Total cost for student program # 3 = 5000

students : student program # 3 (from problem # 1) = 100

Cost/student in program # 3 = $\frac{5000}{100}$

= 50

2	3	All others	Total	To Total	Activity	Share of ES
200	100	170	500	.2	4000	800
200	100	180	500	.2	3000	600
	100	70	200	.5	2200	1100
			10			
			20			
200	100	200	500	.2	5600	1100
			10			
200	60	311	600	.1	8000	800
200	40	160	400	.1	6000	600
						5000

gram # 3 = 5000

am # 3 = 100

$$= \frac{5000}{100}$$

= 50

Total Direct Cost for Program #3 (from solution #8) =

Total Indirect Cost allocated to program

= 1% of Indirect Cost to Academic Program

= (from problem #7)

=

Total Cost in Program #3 = Direct Cost + Indirect Cost

= ___________ + ___________

=

===========

Cost per Student in Program #3 = $\frac{\text{Total Cost in Program \#3}}{\text{Students in Program \#3}}$

= ___________

=

===========

Solution #9: Solution to Total Program Cost Calculation

Total Direct Cost for Program #3 (from solution 8) = $5000

Total Indirect Cost Allocated to Program

= 1% of Indirect Cost to Academic Program

= .01 x $210,000 (from problem #7)

= 2,100

Total Cost to Program #3

= Direct Cost + Indirect Cost

= 5000 + 2100

= $7100

Cost of Student in Program #3 = $\frac{\text{Total Cost in Program \#3}}{\text{Students in Program \#3}}$

$$= \frac{7100}{100} = \$71$$

Problem #10: Calculating Student Loading by using participation rates

Assume the participation rates for program 1 to be as follows:

Biology 102 = 0.1
English 101 = 0.3
ES 120 = 0.2
History 105 = 0.3
Math. 110 = 0.1
Physics 100 = 0.2
Zoology 150 = 0
Math. 110L = 0.1
ES 120L = 0.3
ES 120R = 0

Calculate the number of students in each activity assume 100 students in Program #1.

Problem 10

Program No.1

Activity	Participation Rate	No. of students	Student enrollment by activity
Biology 102	0.1	100	10
English 101			
ES 102			
History 105			
Math. 110			
Physics 100			
Zoology 150			
Math. 110L			
ES 120L			
ES 120R			

Solution: Same as for Problem No. 1.

Appendix II

MANUAL FOR USING UNIVERSITY SIMULATION GAME

by

Hans de Nie(1)

PREFACE

The USG-project was started in May 1972 and resulted in a simulation-experiment in September the same year under the title "SIMULATIESPEL TERTIAIR ONDERWIJS" (Tertiary Education Simulation Game).

This game was played by 300 first year students of the three Utrecht students' clubs participating in the project. After an evaluation in autumn 1972 further extensions to the game were prepared. Contact with the Delft Students' Club led to the opportunity of an amended version of the game being played twice in January 1973, for two groups of 40. This time the "man-simulation" of the first version of the game had been turned into a "man-machine simulation". Thus the technical side of the game is taken care of by a computer, so that a great deal more attention can be paid to the playing of the roles of the various university bodies.

In September 1973, on the basis of a virtually unaltered version of the Delft games, USG was played five times (360 persons).

In co-operation with OMAVO (Department for Organisation and Management Development) of the Utrecht University, especially Mr. Victor Claessens, the target of further evaluation was to make a third version, which could be used for training administrators of faculties in university management. This third version reduced the role of the computer by simulating a letter communication between faculty and university level, instead of entering computer input sheets. Although this is a better simulation of a real life situation and gives the game a more realistic character, it takes much more time to play the game. On the other side this was highly appreciated by players with non-technical background. Also it used the method of curriculum description approved by the Utrecht University Council and developed last year by the "Bureau Personeelsplanning" (Personnel planning department) of Utrecht University and Prof. Dr. J.Th.G.Overbe

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1) University of Utrecht, the Netherlands.

on Management in Higher Education in Paris in November 1974.

1. INTRODUCTION

This manual is concerned with the playing of the University Simulation Game. It will not be concerned with the logic of the game. This is discussed elsewhere (see Chapter 13) in K.M. Hussain's Gaming Models in Higher Education.

The game is designed for administrators and managers at the top level of decision making. Thus the decisions that are made in the game are at the more aggregate level of a "faculty" or "department" and not at the detailed level of determining the teaching load starting with the courses.

There are many values that are fixed for the purpose of the game to simplify the decisions and the running of the game. These are "parameters" and are listed in Section 2. This is followed by a listing of the control variables in Section 3. These are under the "control" of the decision-maker and are thus called "control" or "decision" variables. In a realistic situation many of the parameters would be control or decision variables. In a gaming situation, this could be done but will involve some re-programming of the computer program, and some logistical problems of running the game.

In the game, each team will collectively make changes to one or more of the decision variables. These are done in a real-life situation through correspondence and meetings between the decision-makers and the planning office. Such an environment can also be simulated but this takes a long time in running the game. To reduce this time involved, the changes to the control variables must be made directly on an input sheet designed for convenience of punching the data for computer processing. These forms are those that would also be used in a real situation but completed by the planning office staff rather than the decision-makers. A sample of this form and some explanation of its entries are discussed in Section 4.

Once the input forms are entered with the changed or unchanged decision variables, these are processed by the game staff and soon the results of the decisions are presented to the teams. A sample and an explanation of these output forms are presented in Section 5.

In the game, the output is analyzed by each team and another decision is made specifying another set of decision variables. These are processed again and the cycle is repeated for a finite number of "plays" or computer "runs".

Each game will be played given a set of objectives or/and constraints. These are specified in Section 6. Objectives and strategies not specified or constrained can be determined by each team, before be justified by each team (through a team representative) to the group. The group (of all the teams) along with the seminar staff will then evaluate the decisions as well as the game itself. Hopefully, such an evaluation will result in a learning of the decision-making process especially as it relates to the use of quantitative data and modelling techniques used in higher education.

There is often some learning about the process of decision-making. This is affected by different strategies by the game administrator in relation to the organisation of each team, its size and its composition. Also, the game administrator may change some parameters. Some of these probable strategies are discussed in Section 7.

Finally, there is the problem of communication between team members concerning technical terms used in the game. Some of these terms are defined in a glossary in Section 8.

2. PARAMETERS

A list of the parameters and their respective values are shown in Figure II.1. These values are "fixed" to simplify the game. If they were decision variables instead, they would add to the flexibility of the players but this could also add to the "confusion" and the difficulty in isolating the input that is causing the change in output. This is especially desirable for "games" by players who have never played "games" before. For this reason, this game has more parameters than decision variables.

In playing the game, a player may be frustrated in not being able to change the parameters. He may well question their values and consider them unrealistic. If so, then the game has achieved one of its purposes: to make decision-makers aware of the decision-variables and start (or even provoke) a dialogue on its best values. In a situation where the model is used in a simulation mode, one may even change a parameter and experiment with different values before finding one that is realistic or at least politically feasible. For the purpose of this game, however, the values will be fixed and must be considered a constraint in the game content.

3. DECISION VARIABLES

The decision variables are listed in Figure II.2. A reference of each variable to the logic diagram is shown in the Appendix, to Hussain,op.cit. (Such references are also available for the parameters). Those decision variables that are not self-explanatory are clarified below.

Figure II.1

LIST OF PARAMETERS AND THEIR VALUES

		Value of Parameters
1.	Ratio of hours spent by instructional staff for each hour of student in lecture	2
2.	Ratio of hours spent by instructional staff for each hour spent by student in self-instruction	1.5
3.	Ratio of hours spent by instructional staff for each hour by student in small groups	1.6
4.	Ratio of hours spent by instructional staff for each hour spent by students in laboratories	4/3
5.	Ratio of instructional staff effort to student effort in exams	0.2
6.	Ratio of instructional staff effort to student effort in individual work	0.01
7.	Hours of total effort for each instructional staff for each academic year	2000
8.	Average annual salary for teaching student assistants	$8000
9.	Average annual salary for teaching staff and staff in curriculum development	$26,000
10.	Quality weights for curriculum	
	. lecture	1
	. self-instruction	6
	. small groups	4
	. laboratories	4
	. exams	1
	. individual work	4
11.	Weights for maximum group size	see text
12.	Standard score	248

The decision variables used in any one cycle are listed along with the output results of the cycle. A sample output is shown in Figure II.4 and will be discussed later. The reference of each decision variable to the output sheet is shown in Figure II.2.

There are two sets of decision variables that are in percentages. The first is the distribution of student effort. These percentages (between lectures, self-instruction, small groups, laboratories, exams and individual work) must each be zero or of a positive value and the sum must equal 100 per cent.

The percentage of instructional staff spent on teaching, research and other activities must also equal 100 per cent. However, the effort on "other activities" is a parameter of 30 per cent. Hence the percentage effort of time spent on teaching and research must equal the remainder, i.e. 70 per cent.

LIST OF DECISION VARIABLES

Decision Variable	Reference to output sheet	Constraints in game
1. Number of student hours of effort per year in faculty (in hundreds)	G	
2. Percentage of student effort distribution between		
. Lectures	H	Must total 100%
. Self-instruction	I	
. Small groups	J	
. Laboratories	K	
. Exams	L	
. Individual work	M	
3. Years of study in curriculum	N	Must be + ve
4. Students for all years	U	
5. Maximum group size (at all levels)	V	
6. Teaching staff available (full-time equivalent, i.e. FTE)	O	Can be 0 or + ve
7. Student Assistants available (in FTE)	P	
8. Staff for curriculum development available (FTE)	Q	
9. Percentage of total effort of instructional staff available for teaching	R	maximum 70%

Worksheet # 8 for Calculating Program Direct Cost

Programs			Total	% of 3 to Total	Cost of Activity	Share of ES
2	3	All others				

rogram # 3 =

ent program # 3 =

3 =

The activities in which student effort is distributed may need some definitions and this is done below.

Lectures are presentations to a group of students. In this game there is no restriction or significance of the size of the group for lectures. It is independent of the number of students. If size becomes significant, then it is a "small group" or "lab" and is treated differently (discussed below).

Self-instruction is where a student works on his own. Examples are Computer Aided Instruction and Self-Instruction through audio-visual cassettes. Again, this type of activity is assumed to be independent of the number of students.

Small groups are presentations to a group of students limited to a maximum number of class size. For example, a class of 100 students of 20 will require 5 groups. Another example is a maximum of 16 group size with 98 students will require 6 2/16 groups. The result is rounded upwards to the highest digit, i.e. 7 groups.

Laboratories are similar to small groups but have practical demonstrations or practical work instead of formal class presentations. Rounding is done as in small groups. Note that both small groups and laboratories are student dependent, unlike lectures and self-instruction.

Examinations do have some impact on teaching staff for preparing, proctoring and grading exams. Similarly, individual work has a demand on teaching staff. Examples of individual work activity would be: writing a paper, dissertation or thesis; internship; reading of books; etc.

The decision variable on students is the total number of students in all years of study, i.e. if the curriculum is for 5 years, it is the students in each of the five years at any one time period.

The group size decision variable is for calculating the number of groups or classes. It is relevant only for the small group and laboratory activities.

There are three variables concerned with staff. All affect the cost of the students since they are components of the total cost. The number of teaching staff and student assistants affect the teaching hours available and affect the shortage and surplus of instructional staff. The number of staff for curriculum development is largely related to self-instruction. This latter activity can be only increased by 5 per cent for every 3 staff in curriculum development invested the previous year, i.e. 6 staff in curriculum development in 1973/74 enable an increase in percentage of self-instruction by 2 x 5 = 10 per cent in 1974/75.

A sample of the input sheet for the game is given in Figure II.3. Only the items 1 and 2 need some explanation, the remaining input items having been explained above, in particular under the section for decision variables.

Item 1

Number of identification
Each team will have a number to identify its reports.

Item 2

Number of cycles
This will identify each cycle or run or set of decisions. They will be sequential starting with one. Again this is required for purposes of identifying output.

Figure II.3

USG INPUT SHEET

1.	Number identification of team					1.
2.	Number of cycles (academic year for decision identified as 1,2,3...					2.
3.	Student hours (in 100's)					3.
4.	Percentage lectures					4.
5.	Percentage self-instruction					5.
6.	Percentage small groups					6.
7.	Percentage laboratories					7.
8.	Percentage exams					8.
9.	Percentage individual work					9.
10.	Years of study in curriculum					10.
11.	Number of teaching staff					11.
12.	Number of student assistants					12.
13.	Number of staff in curriculum development					13.
14.	Percentage time spent on teaching					14.
15.	Number of students					15.
16.	Maximum group size					16.

Notes: Data must start from right hand column. For example the number "1" should be entered as follows:

			1

or like this:

0	0	0	1

5. OUTPUT

A sample of the output sheet for the game is given in Figure II.4. Note that the top part (under the heading of "General Data") is the result of the decision. These are followed by a listing of the decision variables and parameters and some intermediate results using decision variables. The decision variables listed should correspond to the values entered in the input sheets and are printed for purposes of checking as well as quick reference.

Each line in the output in Figure II.4 is identified by a letter. This is purely for communication in this manual and does not appear in the actual output. These lines or outputs will now be discussed below.

The net teaching hours (A) and the student hours per year (G) are stated in units of hundreds. The teaching hours (A) is a surplus if no sign is shown (i.e. the + is understood and not printed). If the net value is a shortage, then this is identified by a - sign in front of the numerical value.

The student/staff ratio (B) is calculated with the staff being defined as the staff for teaching and curriculum development, as well as the student assistants. But in the staff/student assistant ratio (C) the staff is interpreted as teaching staff only and not curriculum development staff.

The curriculum quality (D) is an index based on the distribution of student effort between lecture, lab, etc., group size and years of curriculum. The quality score is divided by a parameter to give the quality index.

The total costs (E) and cost/student (F) might sometimes be suppressed. These costs are only salary costs. Total costs are stated in units of ten thousands, cost/student in units of hundreds ($).

The values G-R and U-V are decision variables discussed under input. These are listings of the input for purposes of checking and reference.

The number of groups (W) is a derived value (U/V) and is printed for sake of reference.

The output would be columns of figures corresponding to the values discussed in A-W. The columns could be one or up to 5. These columns would appear in one of two formats. If the results are for one run of one year, then the results would be for up to 5 teams for the same year. Alternatively, the second format would be for only one team but for 1-5 years. An example of the latter format is shown in Figure II.5. This is an actual output. Note that it has no letter identifications for lines as in Figure II.4.

	73-74	REFERENCE
GENERAL DATA		
SHORTAGE/SURPLUS T-HOURS (IN 100'S)	-207.60	A
STUDENT/STAFF RATIO	25.00	B
STAFF/ASSISTANT RATIO	3.00	C
CURRICULUM QUALITY	90.65	D
SALARY COSTS (USD, IN 10000'S)	43.00	E
SAL-COSTS/STUDENTS (USD, IN 100'S)	8.60	F
CURRICULUM		
STUDENTHOURS/YEAR (IN 100'S)	16.00	G
PERCENTAGE LECTURES	40.00	H
PERCENTAGE SELF INSTRUCTION	3.00	I
PERCENTAGE SMALL GROUPS	10.00	J
PERCENTAGE LABORATORY	12.00	K
PERCENTAGE EXAMINATIONS	20.00	L
PERCENTAGE INDIVIDUAL WORK	15.00	M
CURRICULUM YEARS	5.00	N
PERSONEL		
STAFF IN TEACHING	15.00	O
STUDENTASSISTENTS	5.00	P
STAFF IN CURRICULUM DEVELOPEMENT	0.00	Q
PERCENTAGE SPENT ON TEACHING	40.00	R
PERCENTAGE SPENT ON RESEARCH	30.00	S
PERCENTAGE SPENT ON OTHER ACTIVITIES	30.00	T
STUDENTS		
NUMBER OF STUDENTS	500.00	U
GROUPSIZE MAXIMUM	10.00	V
NUMBER OF GROUPS	50.00	W

```
                                           73-74  74-75  75-76  76-77  77-78


GENERAL DATA
SHORTAGE/SURPLUS T-HOURS (IN 100'S)          .56  -1.52   3.40   3.28   1.20
STUDENT/STAFF RATIO                         9.44   9.48   9.37   9.55   9.57
STAFF/ASSISTENT RATIO                       4.40   4.27   4.25   4.08   4.00
CURRICULUM QUALITY                        100.00 100.00 100.00 100.00 100.00
SALARY COSTS (USD, IN 10000'S)            122.40 131.00 142.20 148.20 156.80
SAL-COSTS/STUDENTS (USD, IN 100'S)         24.00  23.82  24.10  23.52  23.40


CURRICULUM
STUDENTHOURS/YEAR (IN 100'S)               16.00  16.00  16.00  16.00  16.00
PERCENTAGE LECTURES                        20.00  20.00  20.00  20.00  20.00
PERCENTAGE SELF INSTRUCTION                 0.00   0.00   0.00   0.00   0.00
PERCENTAGE SMALL GROUPS                    10.00  10.00  10.00  10.00  10.00
PERCENTAGE LABORATORY                      30.00  30.00  30.00  30.00  30.00
PERCENTAGE EXAMINATIONS                    10.00  10.00  10.00  10.00  10.00
PERCENTAGE INDIVIDUAL WORK                 30.00  30.00  30.00  30.00  30.00
CURRICULUM YEARS                            5.00   5.00   5.00   5.00   5.00


PERSONEL
STAFF IN TEACHING                          44.00  47.00  51.00  53.00  56.00
STUDENTASSISTENTS                          10.00  11.00  12.00  13.00  14.00
STAFF IN CURRICULUM DEVELOPEMENT            0.00   0.00   0.00   0.00   0.00
PERCENTAGE SPENT ON TEACHING               35.00  35.00  35.00  35.00  35.00
PERCENTAGE SPENT ON RESEARCH               35.00  35.00  35.00  35.00  35.00
PERCENTAGE SPENT ON OTHER ACTIVITIES       30.00  30.00  30.00  30.00  30.00


STUDENTS
NUMBER OF STUDENTS                        510.00 550.00 590.00 630.00 670.00
GROUPSIZE MAXIMUM                          15.00  15.00  15.00  15.00  15.00
NUMBER OF GROUPS                           34.00  37.00  40.00  42.00  45.00
```

The teams are requested to each act as the head of an academic department such as the "Faculty of Letters". They are to set up their own internal organisation and objectives unless so constrained by the game administrator and announced as occasion arises.

There will be hopefully three decisions. Each will have a specific objective.

Decision 1

To allocate resources for the next year given data as shown on output sheet of starting conditions, and a change in student enrollment and certain environmental conditions (to be announced by the game administrator).

Decision 2

To reallocate resources, based on results of the last decision (decision 1) and changed environmental conditions (to be announced by the game administrator).

Decision 3

All teams will be given the simulated output that would differ from the format of the previous output in at least two ways:

1. It will display projected results of a five year plan.
2. There will be 7 different outputs each with projections of the next 5 years. The 7 outputs would be for 7 different sets of decision variables.

Assume that these are the most interesting sets of alternatives. The problem is: What set of alternatives would you choose? And why?

7. STRATEGIES

The decisions made by teams will sometimes be affected by the strategies adopted by the administrator of the game. For example, he may decide to state one objective for all the teams, such as maximize the quality of curriculum index. Alternatively, he may announce that there is an unexpected change in the availability of funds for higher education and so all instructional staff will be increased by 20 per cent (or decreased by 20 per cent); or the student enrollment has increased or decreased; or the hours spent per year by each student for higher education will be changed by a given percentage. The teams must then reallocate resources in reaction to the changed environment. They must then make hard trade-offs.

It has been stated earlier that the main benefit of the game is the theoretical exercises in resource allocation in higher education, benefit could be insights into the "means" and process of decision-making rather than the "end" result of a decision. This process is greatly affected by the organisation of each team, and its composition and size.

The actual choices and strategies chosen by the game administrator for the organisation, size and composition of teams is a function of the time available to play the game, the number of players, their profile and finally the objectives of the game. These will be announced before the game or during the game.

8. GLOSSARY OF TERMS

CONTROL VARIABLE	See "VARIABLE".
CONSTRAINT	A limitation or restriction. For example, if there are only two rooms of 100 chairs available - then there is a constraint on the rooms of size 100 that are available. The value of this constraint = 2.
CURRICULUM INDEX	See "CURRICULUM QUALITY".
CURRICULUM QUALITY	Is a measure used only in the USG model to indicate the quality of the curriculum offered. It is a function of the type of instruction offered, the class size and the number of years required for completion of the curriculum. The unit of quality is a SCORE calculated by a specified formula. This score is then divided by an ideal value referred to as a STANDARD SCORE to give a QUALITY INDEX.
DECISION	A choice among alternatives. In the game these alternatives in some cases may be limited.
FULL-TIME EQUIVALENT (FTE)	This term is used in reference to staff personnel or students. They can be part-time or full-time. But calculations of cost and loads are based on full-times and not part-time. Hence the part-times are converted to full-time and are referred to as full-time equivalents or FTE.

	Four " " " = 2 FTE Three " " " = 1½ FTE Two quarter-time " = ½ FTE Ten " " " = 2½ FTE An FTE can also be calculated based on his study load.
INDEX	see "CURRICULUM QUALITY".
INPUT	It is a value that goes IN the model or a calculation. Many of these calculations are made on a computer and the data that goes in is referred to as INPUT DATA. These are entered typically on a specific form referred to as an INPUT SHEET which is designed to facilitate keypunching for conversion to data that is machine readable.
INPUT SHEET	See "INPUT".
OUTPUT	This is a reference to computer results calculated by computer.
PROCTORING	The supervision of an exam primarily to answer procedural questions and prevent cheating.
RUN	It is a set of computer calculations made for a set of input data.
SCORE	See "CURRICULUM QUALITY".
STANDARD SCORE	See "CURRICULUM QUALITY".
TEAM	A grouping of individuals that would make decisions for a simulated institution.
VARIABLE	A variable is a data element with a value that changes over the long-range. In the short-term the value may be fixed in which case it is called a PARAMETER. A variable in a planning model is one that is changed by the decision-maker and in this case it is called a DECISION-VARIABLE. Such variables are also under the "control" of the decision-maker and hence also referred to as CONTROL VARIABLES.

Appendix III

MANUAL FOR USING RESOURCE REQUIREMENTS PREDICTION MODEL 1.6

by

Charles R. Thomas(1)

1. INTRODUCTION

This manual was prepared specially for the seminar organized by the IMHE program of the OECD held in Paris in November 1974. It is "special" in that the RRPM 1.6 will be used as a continuation of the gaming exercise provided by USG. Thus only a limited portion of RRPM 1.6 is being used. The part that develops the loading on courses using an ICLM and the part that generates teaching resources are not used. The second part is somewhat similar to the USG, and the first part is somewhat similar to the TUSS, the model used at the University of Utrecht upon which USG was developed.

The logic of RRPM 1.6 is discussed in detail in Clark, D.B. et al., Introduction to the Resource Requirements Prediction Model 1.6. Technical Report 34A, Boulder, Colorado, National Center for Higher Education, 1973. The logic of the model as it pertains to the extension of USG is described in Chapter 13.

In this manual, there will be no discussion of the logic of the model or the principles underlying the decisions for the game. They are discussed in the references cited above. Nor will there be any discussion of the concept of the game and the strategies open to the game administrator. These are the same as those mentioned in the manual for the USG (Appendix II) and in Chapter 13. What will be discussed (or references made to other discussions) are the parameters of the game in section 2; the decision variables in section 3; input preparation in section 4; sample of output in section 5; the problem(s) for the game itself in section 6; and a comparison of USG with RRPM in section 7. Finally, for the players who are not familiar with much of the terminology used for the American context of RRPM, there is a glossary of terms. This is section 8.

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There are too many parameters to be listed conveniently. Identification and specification of the parameters are made in Clark, et al., op.cit.

However, these parameters may change during the game. When changed, the values will be available from the game administrator.

For the purpose of this game played as an extension to USG, further parameters are used. The entire portion of the model concerned up to the calculation of teaching resources is fixed for the game and is hence a parameter. This is done in order not to repeat the part of what was done by USG and instead to enable the players to concentrate on the extension part of the model - that is the calculation of non-teaching expenses.

These parameters in the game are somewhat a realistic situation for some European countries where the teaching staff are civil service employees and their expenses are fixed and are parameters to the university decision-maker. He must then make decisions in the non-academic and non-teaching sectors. This situation is what the extension to the USG by RRPM simulates. It assumes, in short, that the academic sector of teaching is fixed. It is a parameter.

3. DECISION VARIABLES

The teaching sector being fixed, the decision-maker in this version of the game of RRPM 1.6 makes decisions only in the non-teaching sector. Briefly, these are:

- Non-teaching staff for instruction
- Other Expenses for instruction
- Non-instructional "overhead" or support expenses
- Allocation of the above costs to academic programs.

Each of the above decision variables will now be discussed in turn:

1. Staff for academic and instructional purposes for each of the 4 departments. Staff are of at most four categories. These are
   . secretaries
   . clerks or student help
   . teachers or sabbatical
   . other support staff.

To make this decision, use Input form 17, one form for each category, For sample, see section 4 on Input.

2. "Other" Expenses for instruction are for each of the four academic departments. There are at most seven expenditure type categories such as

- . equipment
- . supplies
- . travel
- . printing
- . telephone
- . rentals
- . miscellaneous

To make this decision, use Input form 18. One form for each expenditure type. For sample, see section 4 on Input.

3. Support Expenses (other than academic and instructional expenses).

   The decision maker can choose an unlimited number of categories and, for each of them, he must use one form - Input form 20. For a sample, see section 4 on Input.

   Each category should be numbered by a code identifying a specific category. For purposes of communication, it is suggested that players confine themselves to the classification as shown in Figure III.1.

Allocation of Costs

In calculating total costs for the academic program, one has to allocate costs not incurred directly in the academic program back to the academic program, such as library costs, administrative costs and so on. This can be done by using form 19 (for sample see section 4 on Input).

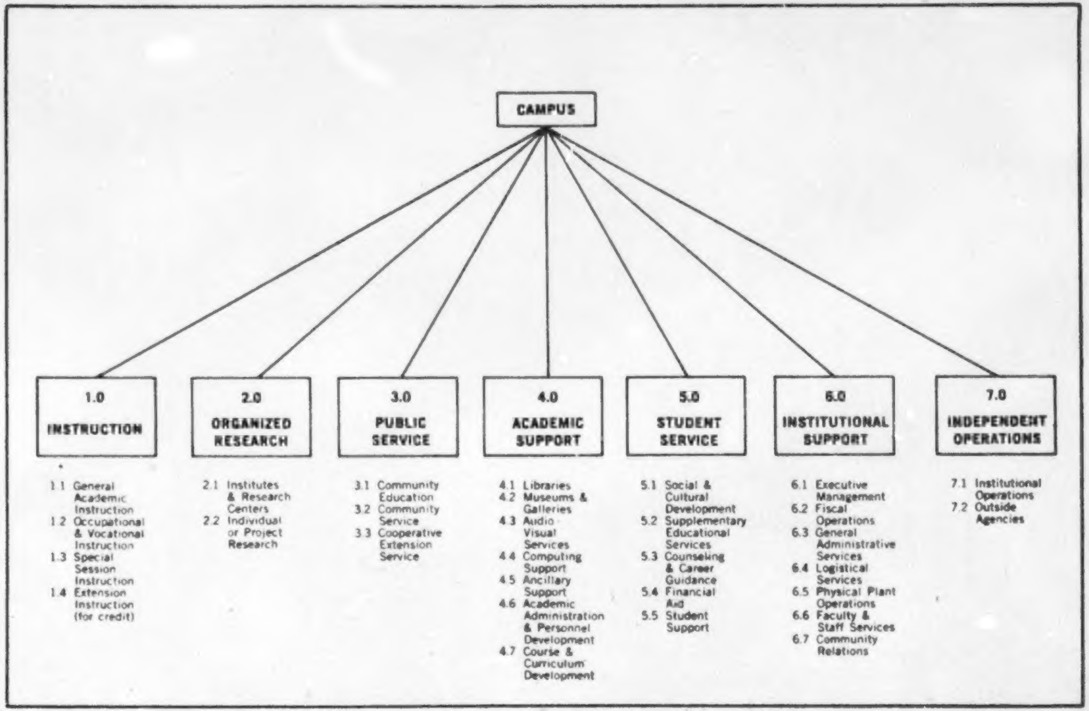
Default Values

There are some decisions that can be anticipated. These values are used if none are specified by the decision maker. These are known as "default" values. They save the decision maker from having to specify values that are obvious and anticipated. If the decision maker does not want these default values, he must specify others.

The default values (if any) are specified on the sample input sheets (see section 4).

The default data is sometimes identified in the output. If so, it is indicated by a "DD" symbol. Similarly, base data is identified by a (**) symbol. These are the values of decision variables with which the simulation started. These values are mostly listed on the original output given to each team at the start of the game.

ORGANISATION OF THE PROGRAM CLASSIFICATION STRUCTURE


CAMPUS
1.0 INSTRUCTION
2.0 ORGANIZED RESEARCH
3.0 PUBLIC SERVICE
4.0 ACADEMIC SUPPORT
5.0 STUDENT SERVICE
6.0 INSTITUTIONAL SUPPORT
7.0 INDEPENDENT OPERATIONS
1.1 General Academic Instruction
1.2 Occupational & Vocational Instruction
1.3 Special Session Instruction
1.4 Extension Instruction (for credit)
2.1 Institutes & Research Centers
2.2 Individual or Project Research
3.1 Community Education
3.2 Community Service
3.3 Cooperative Extension Service
4.1 Libraries
4.2 Museums & Galleries
4.3 Audio Visual Services
4.4 Computing Support
4.5 Ancillary Support
4.6 Academic Administration & Personnel Development
4.7 Course & Curriculum Development
5.1 Social & Cultural Development
5.2 Supplementary Educational Services
5.3 Counseling & Career Guidance
5.4 Financial Aid
5.5 Student Support
6.1 Executive Management
6.2 Fiscal Operations
6.3 General Administrative Services
6.4 Logistical Services
6.5 Physical Plant Operations
6.6 Faculty & Staff Services
6.7 Community Relations
7.1 Institutional Operations
7.2 Outside Agencies

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4. INPUT PREPARATION

Input should be prepared by each team. It should be on prescribed forms, one for each specific decision-variable. The forms are listed below and samples for each form follow. These samples are not to be used but are for reference and explanation. Forms for actual use will be available for each "run" of the game from the game administrator and his staff. These are similar to the sample forms but sometimes without the explanations.

A summary table of the different forms used and the frequency of their use in each "run" or "play" of the game are listed in Figure III.2. Also shown in the table are references to sample forms that follow the Figure.

5. OUTPUT

The output is of three types:

1. Organizational Budget
2. Program Budget including Cost per Student
3. Institutional Summary including Activity Costs.

The Organizational Budget reports can be a large voluminous set of reports because they are at four levels of aggregation:

1. Discipline level
2. Department
3. School/College
4. Institution.

These levels are chosen to correspond to the levels of analysis or decision making. They may or may not correspond to organizational units. For example, Computer Science may be a discipline in the Department of Mathematical Science (along with Mathematics) or it may be a school or college by itself (unlikely but possible).

Now for each discipline within a department there will be an organizational report and for each department in a college there will be an organizational report, then for each college there will be an organizational report and finally there is one organizational report for the entire institution. Thus the reports would be voluminous in a large institution. For the purpose of the game, the number of colleges, departments and disciplines may be reduced or eliminated altogether to keep the game simple. This will be determined and announced by the game administrator. Samples of these reports appear as Figures III.8-III-11.

There is also one report for the entire institution on the Program Budget and cost per student. A sample is shown as Figure III.12.

Figure III.2

SUMMARY OF INPUT FORMS USED

Form No.	Type of Form	Limits on number	Frequency of use	Reference t samples
17	Discipline estimating equation for staff	Maximum = 4 categories	One for each discipline or department or college/school (the lowest level of aggregation	Figure III.
18	Discipline or "other" expense estimating equation	Maximum = 7 types	same as above	Figure III.
19	Allocation of costs to academic disciplines/ programs	One assignment for each course level	same as above	Figure III.
20	Non-academic instructional cost estimating equation	No limit	One form for each type of non-instructional expense	Figure III.

Figure III.2

SUMMARY OF INPUT FORMS USED

e of Form	Limits on number	Frequency of use	Reference to samples
e estimating for staff	Maximum = 4 categories	One for each discipline or department or college/school (the lowest level of aggregation	Figure III.3
e or "other" stimating	Maximum = 7 types	same as above	Figure III.4
n of costs ic disciplines/	One assignment for each course level	same as above	Figure III.5
mic instruc- st estimating	No limit	One form for each type of non-instructional expense	Figure III.6

RECORD IDENTIFIER

S	T	A	F
1	2	3	4

ITERATION

5	6

RESOURCE REQUIREMENTS PREDICTION MODEL

DISCIPLINE ESTIMATING EQUATIONS FOR STAFF

OPTIONAL INPUT

PAGE ____ OF ____

DATE ____________

⑰

Discipline

D				
7	8	9	10	11

Category Code

12	13

Constant ±

			.	
14	15	16	17	18

FTE Faculty Coefficient ±

		.	
19	20	21	22

Student Credit Hour Coefficient ±

.			
23	24	25	26

FTE Chairman Coefficient ±

		.	
27	28	29	30

Staff Salary

				.
31	32	33	34	35

Allocation Method

36	37	38

Sequence

73	74	75	76	77	78	79	80

This input provides the system with the equation for estimating discipline staff other than instructional faculty. It also provides the system with the user-selected method for allocating the cost associated with the other staff to course levels. The allocation methods available are: FTE faculty (FTE); faculty salaries (SAL); student credit hours (SCH); and specific course level (left justified, 2 position). The user is allowed to define a maximum of four categories of "other" staff (i.e., secretaries, student assistants, faculty on sabbatical, clerks). See DEFINITION RECORD 1.

EXAMPLE:

D	0	0	0	1
7	8	9	10	11

0	1
12	13

		1.	0	0
14	15	16	17	18

	5.	0	0
19	20	21	22

F	T	E
36	37	38

Note: If no allocation method is given, FTE faculty is assumed.

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RECORD IDENTIFIER				ITERATION	
E	X	P	N		
1	2	3	4	5	6

RESOURCE REQUIREMENTS PREDICTION MODEL

DISCIPLINE "OTHER" EXPENSE ESTIMATING EQUATIONS

OPTIONAL INPUT

PAGE ____ OF ____

DATE ____________

⑱

Field	Columns
Discipline	D 7 8 9 10 11
Expenditure Type	12 13
Constant ±	14 15 16 17 18 19
FTE Faculty Coefficient ±	20 21 22 23 24
FTE Staff Coefficient ±	25 26 27 28 29
FTE Chairman Coefficient ±	30 31 32 33 34
Student Credit Hour Coefficient ±	35 36 37 38 39
Faculty Salary Coefficient ±	40 41 42 43
Staff Salary Coefficient ±	44 45 46 47
Allocation Method	48 49 50
Sequence	73 74 75 76 77 78 79 80

This input provides the system with the equation for estimating the discipline costs other than staff (i.e., equipment, supplies, travel, etc.). It also provides the system with the user-selected method for allocating the cost associated with the "other" expense to course levels. The allocation methods available are: FTE faculty (FTE); faculty salaries (SAL); student credit hours (SCH); and specific course level (left justified, 2 position). The user is allowed to define a maximum of seven types of "other" expense. See DEFINITION RECORD 1.

EXAMPLE:

D	0	0	0	1	0	1			1	8	5	5.				1	0.	S	A	L
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	48	49	50

Note: If no allocation method is given, FTE faculty is assumed.

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RECORD IDENTIFIER	ITERATION
A D D T	
1 2 3 4	5 6

RESOURCE REQUIREMENTS PREDICTION MODEL

ALLOCATION OF COSTS OTHER THAN GENERAL ACADEMIC INSTRUCTION TO DISCIPLINES

OPTIONAL INPUT

PAGE ____ OF ____

DATE ____________

⑲

Discipline	Course Level	Additional Costs	Course Level	Additional Costs	Course Level	Additional Costs
D		.		.		.
7 8 9 10 11	12 13	14 15 16 17 18 19	20 21	22 23 24 25 26 27	28 29	30 31 32 33 34 35
	Course Level	**Additional Costs**	**Course Level**	**Additional Costs**	**Course Level**	**Additional Costs**
		.		.		.
	36 37	38 39 40 41 42 43	44 45	46 47 48 49 50 51	52 53	54 55 56 57 58 59
	Course Level	**Additional Costs**				**Sequence**
		.				
	60 61	62 63 64 65 66 67				73 74 75 76 77 78 79 80

This input provides a means of allocating noninstructional costs to discipline by level of course.

These data, if entered, may come from some other system, such as Cost Finding Principles.

EXAMPLE:

D 0 0 0 1	L D	1 0 0 0 0.	U D	9 0 0 0.
7 8 9 10 11	12 13	14 15 16 17 18 19	20 21	22 23 24 25 26 27

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RECORD IDENTIFIER

E	S	T	Q
1	2	3	4

ITERATION

5 6

RESOURCE REQUIREMENTS PREDICTION MODEL

ESTIMATING EQUATION FOR COSTS OTHER THAN GENERAL ACADEMIC INSTRUCTION

OPTIONAL INPUT

PAGE ____ OF ____

DATE ________

⑳

Estimating Equation No. 7 8 9 10

Estimating Equation Name* 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

Constant ± 27 28 29 30 31 32 33 34

Enrollment Coefficient ± 35 36 37 38 39 40

FTE Faculty Coefficient ± 41 42 43 44 45 46 47

Student Credit Hour Coefficient ± 48 49 50 51 52 53

Staff Coefficient ± 54 55 56 57 58 59

Faculty Salaries Coefficient ± 60 61 62 63

Staff Salaries Coefficient ± 64 65 66 67

Instructional Budget Coefficient ± 68 69 70 71 72

Sequence 73 74 75 76 77 78 79 80

This input provides the system with the equation for estimating the cost for institutionally defined organizational units other than general academic and vocational instruction (i.e., library costs, physical plant costs, etc.). The user is allowed to define a maximum of 9,889 equations. If the user chooses to incorporate a major heading for grouping-related equations, he simply indicates this by a related numeric value in the higher order position (positions 7 and 8) and zeroes in the low-order position (positions 9 and 10) at the equation number.

Example:

2.00 research
2.02 individual research
2.03 organized research

Note: Estimating equation nos. 0.00 through 01.10 are predefined by the system and may not be user input.

*The estimating equation name is required in order to create this record.

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Type of Output	Occurrence of each type	Reference to samples	Comments
Organizational Budget			
. Discipline	1 for each discipline	III.8	Will most likely be suppressed for game
. Department	1 for each department	III.9	
. School/College	1 for each school	III.10	
. Institution (all levels)	one only	III.11	
Program Budget and Cost/Studies	one only	III.12	
Institutional Summary and Activity cost	one only	III.13	

```
*************************************************          *****************************************************
*                                               *          *  (0011) PHYSICAL EDUC.      DISCIPLINE             *
*       O R G A N I Z A T I O N A L   B U D G E T *        *       (0008) PHYSICAL EDUC.      DEPARTMENT        *
*                                               *          *            (0002) EDUCATION          SCHOOL/COLLEGE *
*************************************************          *****************************************************

                                                                                    PERCENT OF      PERCENT OF
                              SALARY     FULL TIME                                ORGANIZATIONAL  INSTRUCTIONAL
                               RATE      EQUIVALENT     PERCENT          COSTS        BUDGET          BUDGET

CHAIRMAN                      20,686           .29                       5,999         8.28           .3333

FACULTY (BY RANK)
  (FP)  PROFESSOR             17,500           .11         2.45          1,925         2.66           .1069
  (AP)  ASSOC. PROFESSOR      15,000           .90        20.04         13,500        18.64           .7500
  (TP)  ASST. PROFESSOR       11,500           .90        20.04         10,350        14.29           .5750
  (IN)  INSTRUCTOR             9,500          2.58        57.46         24,510        33.84          1.3616
                             -------   -----------      -------   ------------      -------       ---------
  (**)  FACULTY TOTALS        11,199          4.49       100.00         50,285        69.42          2.7935
                             =======                    =======
STAFF (BY CATEGORY)
  (SS)  SUPPORT STAFF          5,214           .44        30.77          2,294         3.17           .1274
  (AD)  ACADEMIC DEAN          8,888           .99        69.23          8,799        12.15           .4888
                             -------   -----------      -------   ------------      -------       ---------
  (**)  STAFF TOTALS           7,757          1.43       100.00         11,093        15.31           .6163
                             =======                    =======
EXPENSES (BY TYPE)
  (SU)  SUPPLIES                                                         3,093         4.27           .1718
  (EQ)  EQUIPMENT                                                          862         1.19           .0479
  (MI)  MISCELLANEOUS                                                    1,102         1.52           .0612
                                                                  ------------      -------       ---------
  (**)  EXPENSE TOTALS                                                   5,057         6.98           .2809

ADDITIONAL EXPENSES
                                       -----------                ------------      -------       ---------
        ***  TOTALS  ***                      6.21                      72,434       100.00          4.0239
                                       ===========                ============      =======       =========

                                            PER-         HOURS    PER-  PERCENT      UNIT            FTE     PER-    PRODUCT.
COSTS BY COURSE LEVEL             COST      CENT      PRODUCED    CENT  TOT HRS      COST        FACULTY     CENT      RATIO

  (LD)  LOWER DIVISION          54,173     74.79           796   85.96     4.17     68.06           3.40    75.72     234.12
  (UD)  UPPER DIVISION          18,261     25.21           130   14.04      .68    140.47           1.09    24.28     119.27
                          ------------   -------   -----------  ------  -------  --------    -----------  -------  ---------
  (**)  CRSE LVL TOTALS         72,434    100.00           926  100.00     4.85     78.22           4.49   100.00     206.24
                          ============   =======   ===========  ======  =======  ========    ===========  =======  =========
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	SALARY RATE	FULL TIME EQUIVALENT	PERCENT	COSTS	PERCENT OF ORGANIZATIONAL BUDGET	PERCENT OF INSTRUCTIONAL BUDGET
CHAIRMAN	20,407	.98		19,999	9.27	1.1110
FACULTY (BY RANK)						
(FP) PROFESSOR	17,500	2.91	27.25	50,925	23.61	2.8290
(AP) ASSOC. PROFESSOR	15,000	3.65	34.18	54,750	25.39	3.0415
(TP) ASST. PROFESSOR	11,500	3.52	32.96	40,480	18.77	2.2438
(IN) INSTRUCTOR	9,500	.30	2.81	2,850	1.32	.1583
(TA) TEACH ASSISTANT	6,800	.30	2.81	2,040	.95	.1133
(**) FACULTY TOTALS	14,143	10.68	100.00	151,045	70.04	8.3910
STAFF (BY CATEGORY)						
(SS) SUPPORT STAFF	5,137	2.76	73.80	14,177	6.57	.7876
(AD) ACADEMIC DEAN	17,958	.98	26.20	17,599	8.16	.9777
(**) STAFF TOTALS	8,496	3.74	100.00	31,776	14.73	1.7653
EXPENSES (BY TYPE)						
(SU) SUPPLIES				1,616	.75	.0898
(EQ) EQUIPMENT				1,873	.87	.1041
(MI) MISCELLANEOUS				2,524	1.17	.1402
(**) EXPENSE TOTALS				6,013	2.79	.3340
ADDITIONAL EXPENSES				6,820	3.16	.3789
*** TOTALS ***		15.40		215,653	100.00	11.9802

COSTS BY COURSE LEVEL	COST	PER-CENT	HOURS PRODUCED	PER-CENT	PERCENT TOT HRS	UNIT COST	FTE FACULTY	PER-CENT	PRODUCT. RATIO
(LD) LOWER DIVISION	25,136	11.66	459	19.94	2.41	54.76	1.49	13.95	308.05
(UD) UPPER DIVISION	63,234	29.32	835	36.27	4.38	75.73	3.20	29.96	260.94
(GD) GRAD DIVISION	127,283	59.02	1,008	43.79	5.28	126.27	5.99	56.09	168.28
(**) CRSE LVL TOTALS	215,653	100.00	2,302	100.00	12.06	93.68	10.68	100.00	215.54

ORGANIZATIONAL BUDGET

(0002) EDUCATION SCHOOL/COLLEGE

	SALARY RATE	FULL TIME EQUIVALENT	PERCENT	COSTS	PERCENT OF ORGANIZATIONAL BUDGET	PERCENT OF INSTRUCTIONAL BUDGET
CHAIRMAN	21,238	2.26		47,997	9.85	2.6664
FACULTY (BY RANK)						
(FP) PROFESSOR	17,500	5.61	22.82	98,175	20.14	5.4539
(AP) ASSOC. PROFESSOR	15,000	7.72	31.41	115,800	23.76	6.4331
(TP) ASST. PROFESSOR	11,500	7.61	30.96	87,515	17.95	4.8617
(IN) INSTRUCTOR	9,500	3.11	12.65	29,545	6.06	1.6413
(TA) TEACH ASSISTANT	6,800	.53	2.16	3,604	.74	.2002
(**) FACULTY TOTALS	13,614	24.58	100.00	334,639	68.65	18.5902
STAFF (BY CATEGORY)						
(SS) SUPPORT STAFF	5,134	5.92	66.67	30,392	6.23	1.6884
(AD) ACADEMIC DEAN	14,864	2.96	33.33	43,997	9.03	2.4442
(**) STAFF TOTALS	8,377	8.88	100.00	74,389	15.26	4.13[illegible]
EXPENSES (BY TYPE)						
(SU) SUPPLIES				6,555	1.34	.3642
(EQ) EQUIPMENT				4,284	.88	.2380
(MI) MISCELLANEOUS				5,959	1.22	.3310
(**) EXPENSE TOTALS				16,798	3.45	.9332
ADDITIONAL EXPENSES				13,640	2.80	.7577
*** TOTALS ***		35.72		487,463	100.00	27.0801

COSTS BY COURSE LEVEL	COST	PER-CENT	HOURS PRODUCED	PER-CENT	PERCENT TOT HRS	UNIT COST	FTE FACULTY	PER-CENT	PRODUCT. RATIO
(LD) LOWER DIVISION	99,518	20.42	1,625	28.88	8.52	61.24	6.03	24.53	269.49
(UD) UPPER DIVISION	158,515	32.52	2,129	37.84	11.16	74.46	8.02	32.63	265.46
(GD) GRAD DIVISION	229,430	47.07	1,873	33.29	9.82	122.49	10.53	42.84	177.87
(**) CRSE LVL TOTALS	487,463	100.00	5,627	100.00	29.49	86.63	24.58	100.00	228.93

```
                                                                                    PERCENT OF        PERCENT OF
                              SALARY     FULL TIME                                ORGANIZATIONAL   INSTRUCTIONAL
                               RATE      EQUIVALENT      PERCENT          COSTS       BUDGET           BUDGET

CHAIRMAN                      22,050          7.92                       174,633        9.70           9.7014

FACULTY (BY RANK)
  (FP)  PROFESSOR             17,627         19.27        22.79          339,675       18.87          18.8700
  (AP)  ASSOC. PROFESSOR      14,970         25.54        30.21          382,330       21.24          21.2396
  (TP)  ASST. PROFESSOR       11,733         25.12        29.71          294,735       16.37          16.3735
  (IN)  INSTRUCTOR             9,565         10.34        12.23           98,905        5.49           5.4945
  (TA)  TEACH ASSISTANT        6,854          4.27         5.05           29,268        1.63           1.6259
                             -------   -----------      -------    -------------     -------        ---------
  (**)  FACULTY TOTALS        13,543         84.54       100.00        1,144,913       63.60          63.6035
                             *******                    *******
STAFF (BY CATEGORY)
  (SS)  SUPPORT STAFF          5,164         23.56        63.03          121,667        6.76           6.7590
  (AD)  ACADEMIC DEAN         15,209         13.82        36.97          210,184       11.68          11.6764
                             -------   -----------      -------    -------------     -------        ---------
  (**)  STAFF TOTALS           8,878         37.38       100.00          331,851       18.44          18.4356
                             *******                    *******
EXPENSES (BY TYPE)
  (SU)  SUPPLIES                                                          46,806        2.60           2.6002
  (EQ)  EQUIPMENT                                                         41,445        2.30           2.3024
  (MI)  MISCELLANEOUS                                                     19,511        1.08           1.0839
                                                               -------------     -------        ---------
  (**)  EXPENSE TOTALS                                                   107,762        5.99           5.9865

ADDITIONAL EXPENSES                                                       40,919        2.27           2.2732
                                       -----------                 -------------     -------        ---------
        ***  TOTALS  ***                    129.84                     1,800,078      100.00         100.0000
                                       ***********                 *************     *******        *********

                                         PER-           HOURS     PER-   PERCENT      UNIT         FTE     PER-    PRODUCT.
COSTS BY COURSE LEVEL          COST      CENT        PRODUCED     CENT   TOT HRS      COST       FACULTY   CENT     RATIO

  (LD)  LOWER DIVISION       576,390    32.02           8,412    44.08    44.08      68.52         30.08   35.58     279.65
  (UD)  UPPER DIVISION       684,796    38.04           7,041    36.90    36.90      97.26         31.65   37.44     222.46
  (GD)  GRAD DIVISION        538,892    29.94           3,629    19.02    19.02     148.50         22.81   26.98     159.10
                       ------------- -------  -----------  -------  -------  ---------    ----------- ------- ----------
  (**)  CRSE LVL TOTALS    1,800,078  100.00       19,082   100.00   100.00      94.33         84.54  100.00     225.72
                       ************* *******  ***********  *******  *******  *********    *********** ******* **********
```

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***********************************************************          ***********************************************************
*                                                         *          *                                                         *
*           P R O G R A M   B U D G E T                   *          *           C O S T   P E R   S T U D E N T               *
*                                                         *          *                                                         *
***********************************************************          ***********************************************************

INSTRUCTIONAL PROGRAM (BY STUDENT LEVEL)                                  PERCENT  PERCENT                        PERCENT   PERCENT
                                          COST PER    NUMBER OF          PROGRAM  TOTAL               PROGRAM      PROGRAM   INSTR
                                          STUDENT     STUDENTS           STUDENTS STUDENTS            COST         BUDGET    BUDGET

   (0001)  HISTORY
           (LD)  LOWER DIVISION             910.92        74.00           39.57     5.54            67,408.08      32.20      3.74
           (UD)  UPPER DIVISION           1,144.93        87.00           46.52     6.51            99,608.91      47.58      5.53
           (GD)  GRAD DIVISION            1,628.00        26.00           13.90     1.95            42,328.00      20.22      2.35
                                       ----------- -----------          ------- -------   ----------------   -------   -------
           (**)  WTD. AVG./TOTALS         1,119.49       187.00          100.00    14.00           209,344.99     100.00     11.63
                                                                        =======                               =======

   (0002)  ENGLISH
           (LD)  LOWER DIVISION             900.65        58.00           36.71     4.34            52,237.70      29.70      2.90
           (UD)  UPPER DIVISION           1,106.33        77.00           48.73     5.76            85,187.41      48.44      4.73
           (GD)  GRAD DIVISION            1,671.53        23.00           14.56     1.72            38,445.19      21.86      2.14
                                       ----------- -----------          ------- -------   ----------------   -------   -------
           (**)  WTD. AVG./TOTALS         1,113.10       158.00          100.00    11.83           175,870.30     100.00      9.77
                                                                        =======                               =======

   (0003)  BIOLOGY
           (LD)  LOWER DIVISION           1,191.67        42.00           39.62     3.14            50,050.14      23.53      2.78
           (UD)  UPPER DIVISION           2,072.45        48.00           45.28     3.59            99,477.60      46.77      5.53
           (GD)  GRAD DIVISION            3,947.98        16.00           15.09     1.20            63,167.68      29.70      3.51
                                       ----------- -----------          ------- -------   ----------------   -------   -------
           (**)  WTD. AVG./TOTALS         2,006.56       106.00          100.00     7.93           212,695.42     100.00     11.82
                                                                        =======                               =======

   (0004)  CHEMISTRY
           (LD)  LOWER DIVISION           1,175.80        32.00           45.07     2.40            37,625.60      27.85      2.09
           (UD)  UPPER DIVISION           2,499.06        39.00           54.93     2.92            97,463.34      72.15      5.41
                                       ----------- -----------          ------- -------   ----------------   -------   -------
           (**)  WTD. AVG./TOTALS         1,902.66        71.00          100.00     5.31           135,088.94     100.00      7.50
                                                                        =======                               =======

   (0005)  PHYSICS
           (LD)  LOWER DIVISION           1,233.97        21.00           52.50     1.57            25,913.37      33.87      1.44
           (UD)  UPPER DIVISION           2,663.14        19.00           47.50     1.42            50,599.66      66.13      2.81
                                       ----------- -----------          ------- -------   ----------------   -------   -------
           (**)  WTD. AVG./TOTALS         1,912.83        40.00          100.00     2.99            76,513.03     100.00      4.25
                                                                        =======                               =======
```

		ESTIMATING EQUATION COEFFICIENTS							
ACTIVITY NAME	ACTIVITY COST	CONSTANT	ENROLL.	FACULTY	STAFF	HOURS	FAC-$	STAFF-$	BUDGET
1.00 INSTRUCTION PGM									
1.10 GENERAL ACADEMIC	1,800,078	1,800,078							
1.40 EXTENSION INST.	95,663	82,303	10.00						
SUB-TOTAL	1,895,741								
2.00 ORGANIZED RSRCH									
2.10 INST.• RSRCH CTR	60,194	34,832		300.00					
2.20 IND/PROJ RSRCH	86,490	44,220		500.00					
SUB-TOTAL	146,684								
3.00 PUBLIC SERVICE									
3.10 CONTINUING EDUC.	12,967	12,122		10.00					
3.20 COMMUNITY SERV.	8,882	4,655		50.00					
SUB-TOTAL	21,849								
4.00 ACADEMIC SUPPORT									
4.10 LIBRARIES	233,794	74,832	100.00	300.00					
4.20 MUSEUM-GALLERY	34,914	28,015	2.00	50.00					
4.40 COMPUTING SUPP.	75,458	53,644	10.00	100.00					
SUB-TOTAL	344,166								
5.00 STUDENT SERVICE									
5.10 SOC-CUL DEVELOP.	440,250	264,380	100.00	500.00					
5.20 SUPPL. EDUC. SER	60,100	60,100							
5.30 COUNSELING/GUID.	47,560	47,560							
5.40 FINANCIAL AID	32,290	32,290							
5.50 STUDENT SUPP	799,910	666,310	100.00						
SUB-TOTAL	1,380,110								
6.00 INST. SUPPORT									
6.10 EXECUTIVE MGT.	168,878	147,064	10.00	100.00					
6.20 FINANCIAL OPER.	52,549	46,986	1.00	50.00					
6.30 GEN. ADMIN. SERV	244,222	207,712	21.00	100.00					
6.40 LOGISTICAL SERV.	103,615	85,559	10.00	55.55					
6.50 PHYS. PLANT OPER	283,889	271,428		100.00		.210			
6.70 COMMUNITY REL.	75,357	73,176	1.00	10.00					
SUB-TOTAL	928,510								

showing the activity cost and the coefficients used for calculating these activities. Here, the activity corresponds to the sub-classifications in the Program Classification Structure as shown in Figure III.1.

This output appears as a sample in Figure III.13.

The sample outputs follow a summary table in Figure III.7 of all the types of reports.

6. SCENARIO AND PROBLEMS

This section may change during the play of the USG game. The changed and other relevant information would be provided to each team at the start of the RRPM 1.6 game.

7. COMPARISON OF USG AND RRPM 1.6

A comparison of USG and RRPM 1.6 in terms of its logic is done in Hussain, op.cit. What is also needed, perhaps, is a comparison of terminology used in the two models. This will hopefully avoid confusion in the playing of the game. Such a comparison is done in Figure III.14 below.

Figure III.14

NON-CONCEPTUAL DIFFERENCES BETWEEN USG AND RRPM 1.6

	USG	RRPM 1.6
Staff	Student Assistants	Student Assistants for non-teaching purposes + other non-teaching personnel in instruction
Teaching personnel	Teaching staff	Faculty includes Teaching Assistants for teaching purposes

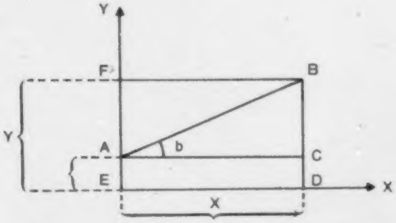
8. GLOSSARY OF TERMS

This glossary of terms is no official or legal document. It is a list of some operational meanings associated with terms as used in the game of RRPM 1.6 for the seminar. Since the readers of this document are Europeans, not all familiar with the American scene for which RRPM was designed, an attempt is made to explain some terms even at the risk of oversimplification.

ACTIVITY Is a subclassification of the program classification structure as shown in Figure III.1.

BASE DATA Are data used as initial values for running the model.

COEFFICIENT It is a value used in estimation. It could well be explained by the figure below:



Consider the value BC. In terms of the horizontal value or known value X and the slope b:

$$BC = b \cdot X$$

where b = coefficient
X = variable

Here b is the slope or rate of change. If X is the number of faculty or staff, then b = faculty or staff coefficient. If X = credit-hour, then b = credit-hour coefficient, and so on.

In other words, it is the rate of change in value for the value of Y when multiplied by X. When b is multiplied by X it gives the variable component of another variable Y.

Now Y may have a FIXED VALUE as represented by AE = a

$$\begin{aligned} \text{Then } Y &= EF \\ &= AE + AF \quad = AE + BC \\ & = a + b \cdot X \end{aligned}$$

COLLEGE See section 5 for example.

CONSTRAINT	A limitation or restriction. For example, if there are only two rooms of 100 chairs available - then there is a constraint on the rooms of size 100 that are available. The value of this constraint = 2.
CONTACT HOUR	This is one hour of "contact" or meeting by a student with instructional staff for formal instruction. It is the basic unit for calculating resources needed for instruction.
CONTROL VARIABLE	See "VARIABLE".
COURSE	A set of lectures or academic activity (like a laboratory or seminar) in pursuance of a prescribed content of academic material.
CREDIT-HOUR	Is a unit of academic achievement used in the U.S.A. and Canada. When a student satisfies the requirements of a course (a specified set of content), which is typically an exam, then he gets accredited to his record of academic achievement a specified number of units referred to as "credit-hours" or simply "credits". When he accumulates a specified number of credit-hours, he then gets a diploma or other academic award. Typically, the credit-hour of a course is equal to the hours that the course meets for a lecture every week. Thus a lecture course meeting three times a week is worth 3 credit-hours. Some courses, however, have instruction other than lectures, such as laboratories, seminars, etc. Typically, these courses meet more often than a lecture course to pursue an activity that is more time consuming. For example, a laboratory in chemistry may meet for four hours a week but have the intellectual content equivalent to a three-hour lecture per week. It then has a 3 credit-hour accreditation even though it meets for 4 hours a week. This latter value of meeting hours per week is also important, especially for its resource implication. It identifies the resources consumed and hence needs to be uniquely identified. It is called "contact-hours" since it represents

the physical contact made with resources such as personnel, space and perhaps even equipment.

The "credit-hour" and "contact-hour" by itself is not an output or consumed resource unless it is achieved or consumed by a student. It then becomes a STUDENT-CREDIT-HOUR and STUDENT-CONTACT-HOUR respectively.

The above terms (and the FTE term) can perhaps be best understood by the illustration of a numerical example given below:

Problem: Calculate the output of the courses Theology 452 and Chemistry 102 given the following data:

1 FTE student = 15 student-credit-hours

Theology 452

meets 3 hours weekly with
3 credit-hours

has 30 students

Chemistry 102

meets 3 hours weekly for lecture and
4 hours weekly for lab
with 2 hours' credit (for lab-Chem 102L)
has 20 students for the lecture
and 15 students for the lab.

Solution:

		Theology	Chemistry		Source
			102	102 L	
1	Credit-hours	3	3	2	Given data
2	Students	30	20	15	Given data
3	Student-credit-hours	90	60	30	3 = 1 x 2
4	FTE student	6	4	2	4 = 3 / 15
5	Contact-hour	3	3	4	Given data
6	Student Contact-hour	90	60	60	6 = 2 x 5

DATA A value that represents an observation, fact or estimation.

VARIABLE	
DEFAULT DATA	Is data used for the value of a decision variable if its value is not otherwise specified.
DEPARTMENT	See section 5 for example.
DISCIPLINE	See section 5 for example.
ESTIMATION EQUATION	See section 5 for a detailed discussion.
EXPENSES	Same as costs incurred or expenditures incurred.
FACULTY	A teaching staff member with one of 5 ranks Professor Associate Professor Assistant Professor Instructor Teaching Assistant
FULL-TIME EQUIVALENT	This term is used in reference to staff personnel or students. They can be part-time or full-time. But calculations of cost and loads are based on full-times and not part-time. Hence the part-times are converted to full-time and are referred to as full-time equivalents or FTE.
Examples:	Two half-time personnel = 1 FTE Four " " " = 2 FTE Three " " " = $1\frac{1}{2}$ FTE Two quarter-time " = $\frac{1}{2}$ FTE Ten " " " = $2\frac{1}{2}$ FTE
	An FTE can also be calculated based on his study load. For example, see "CREDIT-HOUR".
INPUT	It is a value that goes IN the model or a calculation. Many of these calculations are made on a computer and the data that goes in is referred to as INPUT DATA. These are entered typically on a specific form referred to as an INPUT SHEET which is designed to facilitate keypunching for conversion to data that is machine readable.
INPUT SHEET	See "INPUT".

LEVEL	This is a stage in the student's passage through university. It corresponds to each year at the university. Thus a second level student is in his second year of prescribed and recognized study. Similarly, a third year course level would be the courses primarily designed for the third year student. In RRPM 1.6, courses are aggregated and characterized in 3 levels as follows: Lower division: First two years in a college or university Upper division: Second 2 years in a college or university, i.e. 3rd and 4th year. Graduate division: Years above 4th year typically for a Masters or doctoral degree.
"OTHER" EXPENSES	These are expenses or costs other than salaries (e.g. supplies, travel, communication, etc.)
OUTPUT	This is a reference to computer results calculated by computer.
PARAMETER	See "VARIABLE".
PRODUCT-RATIO	Is an abbreviation of "productivity ratio". It is the average number of credit-hours produced by each FTE faculty member that is teaching. It may vary with levels and disciplines.
RUN	It is a set of computer calculations made for a set of input data.
SALARY RATE	This is the annual salary for an FTE person. It is for an academic year for teaching personnel and for a calendar year for support (non-academic) personnel.
SCHOOL	See section 5 for example.
STAFF	Personnel employees in a non-teaching position supporting the teaching personnel.
STUDENT	This is a FTE student not a part-time student. All part-time students are converted to FTEs.

STUDENT ASSISTANT	Is a student who can be a faculty member if he has teaching responsibilities or a support staff member if assigned non-teaching responsibilities.
STUDENT-CONTACT-HOUR	See "CREDIT-HOUR".
STUDENT-CREDIT-HOUR	See "CREDIT-HOUR".
SUPPORT	Non-teaching activities in "support" or helping teaching activities.
UNIT COST OF PRODUCTION	It is the cost per unit of production. This unit may be credit-hours or contact-hours.
VARIABLE	A variable is a data element with a value that changes over the long-range. In the short-term the value may be fixed in which case it is called a PARAMETER. A variable in a planning model is one that is changed by the decision-maker and in this case it is called a DECISION-VARIABLE. Such variables are also under the "control" of the decision-maker and hence also referred to as CONTROL VARIABLES.

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